Barley Production in Alberta

Alberta

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Introduction

The objective of this manual is to provide the grower with information that will help him to maximize barley production for the greatest dollar return per unit area grown.

The information presented is a composite of the latest research and producer information. The producer information was obtained through a survey of 325 above-average barley growers situated in central Alberta.

The survey, conducted in the fall of 1981, covered the dark brown, thin black, black and grey wooded soil zones. Twenty-four district agriculturists selected successful producers in their area to complete an extensive (41 page) questionnaire. The data were sorted into two groups — a top yield group (average 93.5 bu/acre) and a low yield group (average 48.7 bu/acre). The effect of abnormal moisture on yield was eliminated from the data by selecting only farms that received adequate rainfall throughout the growing season. A comparison of the various management factors contributing to this 92% average yield increase is contained in this manual. The survey results are highlighted in shaded areas. Research information came from many sources, but primarily from results obtained by Canada Agriculture in the prairie provinces.

The main emphasis of the manual is on production. The grower must consider the cost of the extra units of production in order to maximize profit.

History

Barley was cultivated long before recorded history and its origin is uncertain. It probably originated as a cultivated crop in Asia Minor or the Middle East. Archeological remains indicate that it was cultivated as early as 7000 B.C. in Iran. By 6000 B.C. it had become probably the most important cultivated plant of the region, a position it maintained until more recent historic times, when it was largely supplemented by modern wheat as the principal food crop.

French settlers brought barley to Canada. In 1721 nearly 100 tonnes (4,585 bushels) of barley were produced in Canada. During the American Civil War a feed shortage developed which led to Canada's first barley export.

Six-rowed varieties of the Manchurian type were the first to be grown in the west because of the preference of North American maltsters. O.A.C. 21 became the predominant variety, but it was confined to parkland areas. It was not suitable for grassland areas because it was susceptible to damage by heat, drought, and high winds. Although relatively low-yielding, it was a useful alternative to wheat because of its early maturity. Then, as now, most of the barley produced in the parkland was fed to livestock, but the amount sold in the malt market provided important cash income.

Varieties suitable for the midwestern United States were not available until recently, and American maltsters had to depend on barley from Canada. This market reached its peak in the early 1950s when it exceeded 655,000 tonnes (30 million bushels) per year. Excellent breeding programs were established in the midwest after World War II, and by 1960, suitable six-row varieties were becoming available for the area. Today the United States produces most of its own requirements for six-row malting barley, and the Canadian export market for this type has consequently declined. Offsetting this decline has been the increased domestic demand for barley as a cattle feed.

The decreasing demand for six-row malting barley from Canada has been accompanied by an increasing demand in the U.S. for two-row barley. Suitable varieties have been introduced into Alberta to meet the requirements for that market. Before World War II, two-row varieties were of minor importance in western Canada, and industrial use was confined largely to pearling, a very minor market. The introduction of the two-row variety, Compana, into southern Alberta in the late 1940s provided for the first time an economically viable alternative to hard red spring wheat on the open prairies. Later, in 1960, Betzes was licensed, providing a variety reasonably well suited for grassland areas, and of acceptable malting quality. Klages was licensed in 1977 and is now the preferred two-row variety for malting.

In recent years the most rapidly expanding market for two-row malt barley has been the Pacific countries, primarily Japan. Exports of six-row malt to Central America have been relatively stable.

Utilization

Barley was first cultivated as a food crop for human consumption. It still forms a part of the diet in some areas of the world, where short seasons or drought preclude the cultivation of other cereals. Its use as food has been largely replaced by more palatable cereals, primarily wheat and rice. The major use of barley today is for livestock feed.

The second largest use of barley is for malting and most of the malt produced is used for brewing beer. Much smaller amounts of malt are used for distilling, and very limited amounts used in making breakfast cereals, dark beers, and as food flavoring. It is used extensively in preparing infant foods, and to produce malt syrup for medicinal, textile, and baking use. Spent grains are an excellent high protein feed supplement.

A small amount of barley is pearled in Canada each year for use in soup and in the manufacture of baby food. Some barley flour is produced as a by-product of pearling, and is used in the preparation of breakfast cereals and baby foods.

Current Production

Canada is now the third largest barley producer in the world, with an average annual production of nearly 11 million tonnes (500 million bushels). This is 6% of world production, compared with 31% produced by the U.S.S.R., and 11% by the Peoples Republic of China.

The following Statistics Canada figures show average barley production for the years 1976-1981:

TABLE 1 — AVERAGE BARLEY PRODUCTION

	Thousand Tonnes	Million Bushels
Alberta	5,476	252
Prairie Provinces	10,171	467
Canada	10,926	502

The figures show that most of the Canadian barley crop is produced on the prairies with about half coming from Alberta. It is often Alberta's most important cultivated crop in terms of acreage and total production. Barley is a versatile crop well suited to Alberta's soil and climate, consistently yielding more weight of grain per unit area of land than hard red spring wheat in all agroclimatic zones.

Current Markets

The average production and disposition of the prairie barley crop for the 5 crop years, beginning in 1975 and ending in 1980, was as follows:

TABLE 2 — PRAIRIE BARLEY DISPOSAL

Barley	Thousand Tonnes	Million Bushels
Shipments to Brewers and Maltsters	627	29
Malting Barley Exports	355	16
Total Malting	982	45
Total Feed, Seed, Others	8,524	392
Average Total Production	9,506	437
Canadian Wheat Board Marketings	3,884	178

(Sources — Statistics Canada, Canadian Wheat Board and Canada Grain Commission)

Only 40% of the total prairie barley crop was marketed through the Canadian Wheat Board. The remainder was sold through the non-board market, or retained on the farm for feed, seed, and local sales. Although only 10% of the total production was used for malting, 25% of C.W.B. marketings were used by the malting industry.

Canada is the world's largest barley exporter, averaging, from 1976 to 1980, 3,794,000 tonnes. Barley is exported as grain for feed and malting, and as processed malt. Major markets for feed barley are Japan, U.S.S.R., and Italy. Outside North America, virtually all barley used for beer production is two-row, and, except for special purposes such as distillers malt, malting barley and malt offered for export must be high quality two-row. Canada exports malting barley to the United States, Europe, and South America. Canada is the world's third largest malt exporter, and exports have increased significantly in the past 10 years. Most exported malt is shipped to Japan and other Asian countries, with smaller quantities going to the United States, Central and South America, and Western Europe.

Adaptation

Barley has the widest area of adaptation of any of the major cereals. It is widely grown in the temperate parts of the world, and is also found on plateaus of Tibet and Ethiopia, and in the Andes mountains of Peru. It is grown from the semi-arid areas of the Middle East to as far north as Norway and Alaska. It is man's most dependable crop where there are saline soils, summer frosts or droughts.

However, of the major cereal crops, barley is the most sensitive and responsive to the environment. Its wide distribution is the result of very wide genetic variation within the crop, with specific varieties adapted to specific environments. While a good variety may be grown over a wide range of environments, it will achieve its maximum production only in its home or a very similar environment. Varieties can be transferred from one region to another, and may perform reasonably well, but the most productive varieties in an area are those bred in that area. While this applies to all cultivated crops, it is more important in barley than in some less sensitive crops such as common wheat.

Variety Adaptation — Of the varieties currently grown in Alberta, six-rowed types occupy about 60% of the acreage sown, and two-rowed varieties the other 40%. Their distribution is associated with climate. Six-rowed varieties predominate in the relatively moist Census Divisions 7 to 15, (Figure 1), and tow-rowed types are preferred in the more arid Census Divisions 1 to 6. Among our present varieties, the two-row character seems to be associated with better drought and shattering resistance — major adaptive factors on the open plains. The six-rowed varieties tend to mature earlier and have better lodging resistance — major factors in parkland areas. However, these generalizations cannot be applied to individual varieties, and a producer should consult the latest variety recommendation list, published each year, before deciding on a variety for his locality.

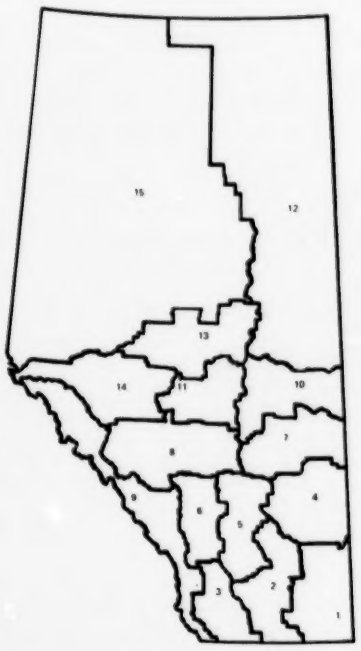

FIGURE 1. Map showing Alberta census divisions, 1980.

Six-rowed feed varieties are the highest yielding when soil fertility, climate and moisture allow maximum expression of potential yield. For example, Klondike has consistently yielded more than other varieties available from 1976 to 1981 at Lacombe and Edmonton, where fertile soils and adequate rainfall contribute to very high yields. In contrast, at Lethbridge, the six-rowed variety, Galt, has outyielded Klondike, even on very fertile soils under irrigation. Galt seems to tolerate drying winds and lower humidity better than Klondike. Under very dry conditions the two-rowed varieties usually outyield six-row varieties. Hector, a two-row, yields more than Galt; is equal to it under moderate yield conditions, but lacks the genetic ability to equal Galt under high yield conditions.

The higher yield potential of six-rowed feed types is an indication of the greater breeding effort directed to the six-rowed types in the past. The very rigid quality requirements for malting barley make yield and agronomic improvements more difficult and expensive to attain compared with feed barley. The original breeding programs done in western Canada were located in parkland areas and concentrated on six-row feed types, while serious efforts at improving two-row feed types were not established until the 1950s.

See Appendix 1 for a description of current varieties.

Areas for Malting Barley Production — Normally 2 to 5% of Alberta's barley is graded 1CW or 2CW six-row and from 8 to 10% as 1CW or 2CW two-row. The following table gives the range in estimates of the proportion of the crop for each Census Division that entered the various grades during the 6-year period 1976-1981.

TABLE 3 — QUALITY OF ALBERTA BARLEY — 1976-1981

Census Division No.*	CW 6-Row %	CW 2-Row %	Feed %
1	1 — 12	16 — 32	65 — 83
2	2 — 5	21 — 36	60 — 76
3	1 — 4	11 — 25	73 — 85
4	1 — 5	0 — 13	85 — 99
5	2 — 6	21 — 38	56 — 76
6	3 — 7	7 — 17	74 — 90
7	2 — 6	3 — 8	86 — 94
8	1 — 8	1 — 7	85 — 99
10	1 — 4	1 — 2	94 — 98
11	1 — 5	0 — 1	95 — 99
12	0 — 1	0 — 1	99 — 100
13	0 — 2	0 — 2	96 — 100
15	1 — 5	1 — 5	91 — 97

*See Census Division Map — Figure 1

These figures give a good indication of the probability of producing acceptable malting barley in any area of Alberta. The producer must weigh the costs of the lower yields he would get, and the probability under his growing conditions of meeting the higher quality malting barley standards, against the associated malting monetary premium. The premium paid to farmers for malting barley has generally ranged between $6.90 to $69.00 per tonne ($0.15 - $1.50 per bushel).

In many areas the possibility of obtaining malting barley is so slight that the producer, on the average, will increase his returns by growing the higher yielding feed type varieties.

Malting barley is a specialty crop. In many respects quality standards are similar to those of pedigreed seed. High quality malting barley will have the following characteristics:

1. A pure lot of an acceptable variety.
2. High percentage germination and vigorous growth. The grain must be mature, dry and free from disease, frost damage, weathering, peeled and broken kernels, heat damage, or sprouted kernels.
3. Plump kernels of uniform size.
4. Low to moderate protein content — 9% to 12.5% dry basis.

Maltsters prefer to process a limited number of varieties in order to avoid numerous adjustments in the malting procedures and greater storage costs. Varietal purity is especially important because acceptable varieties differ in such characteristics as rate of water absorption and germination rate, requiring a somewhat different treatment for each during the malting process. Even with the right variety and good management, drought that occurs when the crop is maturing can result in an unacceptably high protein content, or wet harvest weather can result in weathering and sprouting. Harvesting methods are also an important factor and are discussed on page 27.

Days to Maturity — Maturity in barley is usually measured by the number of days from seeding to harvest. For a particular variety this figure will vary considerably depending on location, season, and date of seeding. It tends to be lower in the southern part of the province because of increased heat units. This is partially offset by longer day lengths as we move northward. (e.g. at Fort Vermilion, the number of days to maturity is less than at Lethbridge.)

Days from seeding to maturity are reduced by late seeding. Plantings of the same variety at dates as much as a month apart may mature within a period of about a week. However, varieties tend to maintain their relative maturities regardless of environment. Maturity differences can be increased or decreased by location, length of growing season, and sowing date, but varieties will mature in the same order. Maturity differences are compressed by late seeding, and varieties that may differ in maturity by as much as two weeks when sown early will mature within a period of a few days when sown late. Yield from the late sowing will be lower because of the reduced length of the growing period, shorter days, and consequent reduction in time available to produce dry matter.

Factors Affecting A Farmer's Decision To Grow Barley

Though market prospects will govern one's decision to grow barley, few cereals can be grown under such diverse cultural and cropping practices as barley. It may be grown under a wide range of soil and climatic conditions. However, like most cereals, truly successful barley

production depends on diligent attention to the cropping history of fields, as well as carefully planned and well-executed cultural practices. The following five factors should be considered:

Cropping History

Fields that have a history of repetitive soil erosion by wind or water should not be used for cereal production. They should be sown to soil-stabilizing crops of grasses and legumes. Fields with serious weed or volunteer grain problems should only be considered for barley production if the weeds and undesirable grain can be controlled by tillage or with herbicides that can be tolerated by barley (see page 20 for chemical weed control). Serious weed infestations witll reduce crop yields and may lower the market grade of the grain as well as its acceptability for feed or malting.

The possibility of disease organisms, toxins and insects being harbored in, or transferred from, the trash of a previous crop, or from the soil to the barley crop, must be recognized. In southern Alberta, when seasonal precipitation is low, the presence of large amounts of residue from a previous canola crop may reduce the yield of all varieties of subsequently grown barley. The yield reduction may occur even though germination and plant stand of the barley was not adversely affected by the water-soluble toxin present in the canola residue. Other cereal crops are similarly affected. In central and northern Alberta, where precipitation is usually more plentiful, the toxin is normally leached into the soil before it can affect plant growth. A good straw spreader helps reduce the risk from the canola residue toxin.

Land Topography and Soil Texture

Barley will grow successfully on almost any topography or land conformation that can be cultivated, provided other conditions do not limit growth. Medium textured soils such as loams, clay-loams and silty-clay loams are generally suitable for barley production. Most agricultural soils in Alberta fall within these textural classes.

The survey showed that there was no yield difference between soil zones (dark brown, thin black, black, grey-wooded) but soil texture did affect yield. Seventy-five percent of the top producers grew their barley on loam to clay loam soil, compared to forty-five percent of the low producers. Fifty-five percent of the low group grew their barley on sandy loam to sandy clay loam, whereas only 25% did in the top group.

Problem Soils

Saline Soils — Saline or salty soils that will no longer support the growth of wheat, oats or oilseeds may still be suitable for barley production although yields will likely be reduced. Barley is more tolerant to soil salts than most other cereal crops, and may tolerate as much as 12 mmhos electrical conductivity; spring wheat and oats about 9 mmhos and canola-flax about 6 mmhos. Electrical conductivity is a measure of the total soluble salt concentration in a soil.

There are more than 300,000 ha of saline soils in Alberta, most of which are located in the southern half of the province. Most saline soils have poor internal drainage.

Good stands of barley, of somewhat delayed maturity, have been grown on soils that contain as much as 1.6% of mixed sodium and magnesium sulfates. Though these are excessively high values, they indicate the possibility of growing barley in special areas if moisture conditions are favorable. Six-row barley generally out-yielded two-row barley which, in turn, outyielded wheat and oats when grown on saline dryland soil in southern Alberta. Galt and Klondike were the most salt-tolerant six-row varieties, and Fairfield and Hector of the two-row varieties tested.

Generally, the more saline the soil, the greater the difficulty in growing any crop — even barley. Figure 2, published by the Saskatchewan Department of Agriculture, gives an indication of the yield response to various salinity levels among seven different crops.

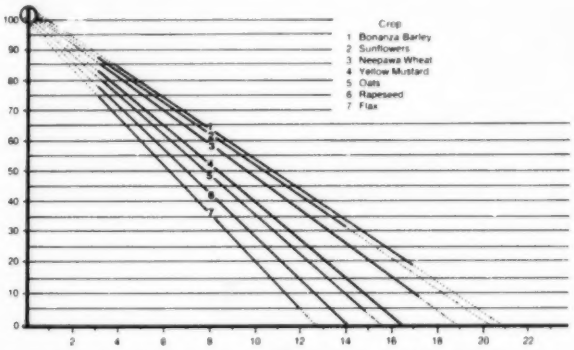

FIGURE 2. Yield response of various salinity levels of seven crops. The steeper the slope line the less tolerant the crop. Note: the solid portions of slope lines are known values. The dotted portions are projected values.

Acid Soils — There are more than 3.5 million ha of agricultural soil in central and northern Alberta where barley yields are reduced by soil acidity. Soil acidity can be determined by any reputable soil-testing laboratory and is expressed as a pH value. A pH value of 7.0 is neutral. In practical terms, a soil below pH of 6.5 is called 'acid', and above 7.5 is 'alkaline'.

The following is a list of crops showing the lowest pH value they will tolerate without yield reduction:

TABLE 4 — ACIDITY TOLERANCE OF VARIOUS CROPS

Alfalfa, sugar beets	6.5
Barley, red clover	6.0
Canola, wheat, corn	5.5
Potatoes, rye	5.0
Cranberries, oats	4.5

More than 30% of the soils in the Peace River region of Alberta have pH values of less than 6.1. In the thin black and dark brown soils north of the Bow River, 28.0 and

19.9%, respectively, have pH values less than 6.1. Though barley varieties differ in sensitivity to soil acidity, all varieties grown in Alberta appear to be less tolerant of acid conditions than oats, wheat or canola. It is difficult to obtain high yields of barley on strongly to very-strongly acid soils (pH 5.5 to 4.5) without first liming the soil. Yields of barley grown on such acid soils have been increased by as much as 15% when lime was added to the soil, provided phosphorus was not limiting. Limited research in the Peace River region indicates that Olli is more tolerant to soil acidity than a number of other current varieties tested.

A small percentage of the surface soils in the brown soil zone of southeastern Alberta are slightly acidic, but the response to added lime on these soils is unknown.

Solonetzic Soils — Solonetzic soils, with their inherent variability and physical conditions, present management problems that are unique. They are often called "burn out or hardpan soils", and are characterized by a tough, impermeable hardpan, that may be 5 to 30 cm below the soil surface. This hardpan layer severely restricts water and root penetration below the topsoil.

With careful management, reasonably good crops of barley can be grown on all but the most strongly developed solonetzic soils. Special attention must be given to surface drainage, time and method of tillage, seedbed preparation, seed placement and crop fertilization.

Where barley is grown on irrigated solonetzic soils, it is important to maintain the soil at the correct moisture content by proper irrigation scheduling. Frequent light irrigations are required to maintain soil moisture levels higher than in normal soils. New automated sprinkler systems appear to be ideally suited to meet the special requirements of irrigating these soils.

Soil Moisture Situation

In Alberta, most barley is grown on dryland. About 20% of the barley is produced on fallow land and 80% on stubble land. Whether to seed barley on fallow or on stubble land should generally be governed by a knowledge of the amount of moisture that will normally be available to the crop, either as soil-stored moisture, or as rainfall to be received during the growing season.

Barley needs about 25-30 cm (10-12 in.) of water to produce a satisfactory crop on dryland. When it is grown on irrigated land it will use somewhat more than 25-30 cm of water to produce the higher yields expected. In most of the thin black, black, and grey-wooded soil zones of Alberta, seasonal precipitation (May 1 to Sept. 30) exceeds 25 cm (see Figures 3 and 4). This rainfall provides nearly enough moisture to grow barley annually without relying on stored soil moisture which is normally present. Barley can be grown successfully as a stubbled-in crop in these regions.

In parts of the dark brown and brown soil zones, seasonal precipitation may not be adequate to meet the needs of a barley crop without relying on stored soil moisture. Stored soil moisture therefore is very important.

The amount of water that can be stored in a soil depends on the texture of the soil. It can be calculated roughly by measuring the depth to which the soil is moist. Moist soil will form a ball when it is squeezed in the hand. The amount (cm) of plant available water stored in equal depths of the various textural classes of soil is shown in Table 5.

TABLE 5 — STORED SOIL MOISTURE

Soil Texture	Approx. Depth of Plant Available Water in Soil	
	CM/30 cm Soil	Inches/Foot Soil
Heavy (Clays and Silty Clays)	5.0	2.0
Medium (Clay Loams, Silt Loams, Loams)	3.75	1.5
Coarse (Sandy Loams and Sands)	2.5	1.0

From a knowledge of stored soil moisture reserves and expected average growing season precipitation one can assess the advisability of seeding barley on stubble land or on fallow.

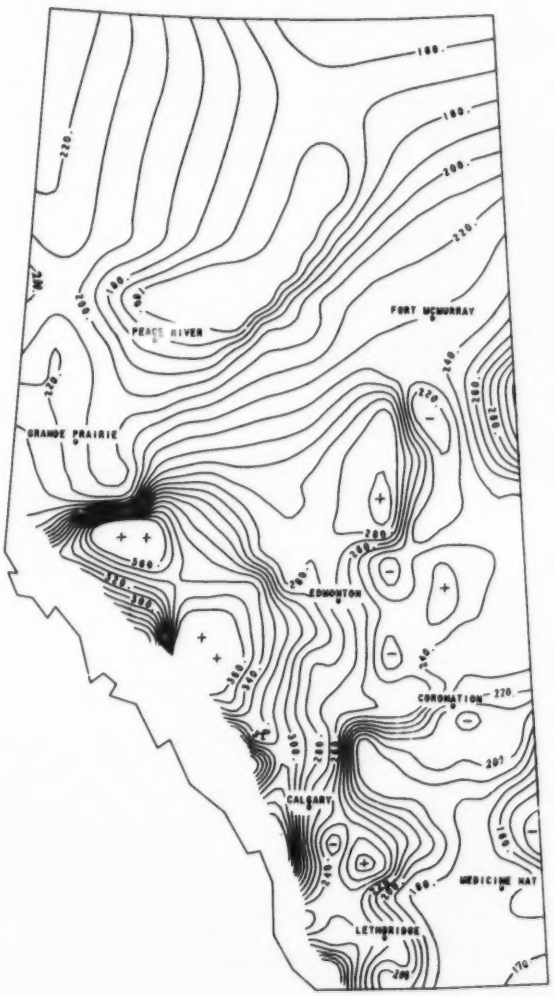

FIGURE 3. Map showing average seasonal precipitation (mm) in Alberta (May 1 - August 31).

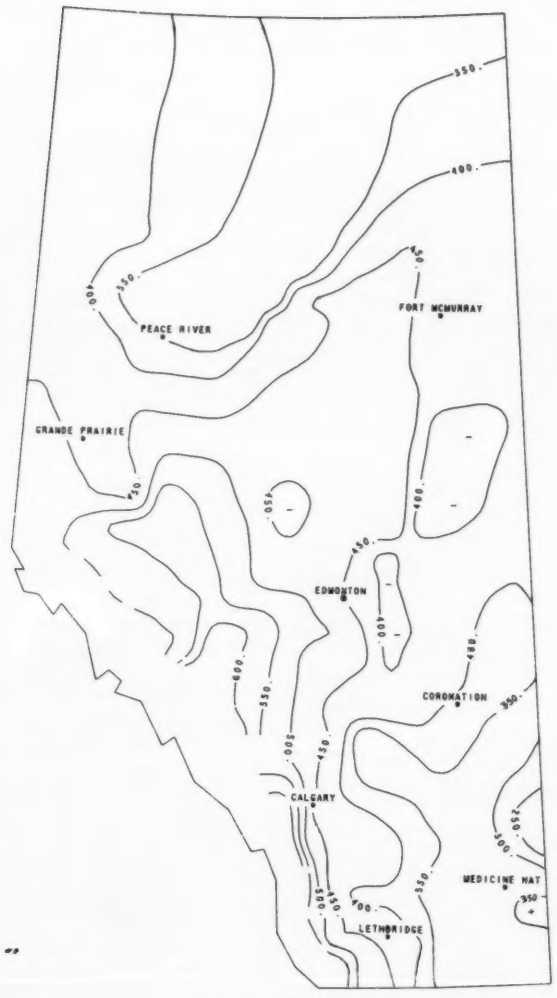

FIGURE 4. Map showing average annual precipitation (mm) in Alberta.

Frost-Free Period

The average length of frost-free period in parts of the Peace River region and much of the southern third of Alberta ranges from 90 to 130 days (Figure 5 — Map showing average number of frost free days in Alberta). Under good management, and in most years, there should be little or no difficulty in maturing the recommended varieties of barley for Alberta in these areas.

At higher elevations, along the southwestern boundary of the province, and in other localized areas such as near Three Hills, the frost-free period is often too short to properly mature barley. Some barley may be grown in areas with less than about 90 frost-free days, but producers should expect frost damage to the partially filled heads in the fall. In the spring, frost damage to barley seedlings is usually not severe enough to kill the plants, though they may be retarded a few days. See page 26 for information on frost damage.

Preparing Land For Barley Production

Land preparation for barley production will vary between soil zones, soil types, and with years. It will depend on soil moisture, weeds, previous crop, trash cover, soil erodability, fertilizer requirement and machinery availability.

No-Till Land Preparation and Production

In some areas barley may be grown as a no-till crop, either alone or in rotation with other cereals and chemical fallows. As the name implies, no regular tillage of the soil, other than that incidentally afforded by fertilizer and the seeding machinery, is performed. The barley seed is planted into nontilled soil, and in-crop weeds are controlled with selective herbicides. Postharvest volunteer grain growth and weeds are controlled with wide-spectrum herbicides. Barley grown as a no-till crop in rotation with other cereals may contain volunteer grain of other species and varieties.

Because soils under no-till culture are often cooler than tilled soils, no-till production may not be suitable in some central and northern parts of Alberta where the growing season may be too short. Heavier trash residue in these areas also impedes implementation of no-till practices because currently available seeding equipment has trouble with heavy trash.

Barley Production on Fallow Land

Good fallow land intended for barley production the following year can be prepared and maintained with a wide range of tillage implements operated alone, or in conjunction with broad-spectrum herbicides. Where crop residues are sparse, it may be advantageous to control initial weed growth with fall or spring-applied herbicides, since tillage normally reduces protective trash covers and soil moisture. Tillage should be as shallow as possible, on all normal soils, consistent with good weed control. Sufficient trash cover must be maintained on all fields to protect the soil from erosion and structural damage throughout the fallow period. Plowing normally buries all surface residue and may leave the surface subject to erosion.

Disc-type tillage implements reduce trash covers by about 50% with each operation. Heavy duty cultivators, or blade cultivators, reduce trash covers by only 10-15% with each operation, and therefore, leave the surface soil reasonably well protected from erosion.

When partial fallows are often prepared by breaking grass or grass-legume sod, such breaking should be done before July to allow time for mineralization of the nutrients in the newly incorporated plant material. Late fall plowing of the tilled sod may provide good control of any grass regrowth and should leave the soil in a satisfactorily rough condition to resist winter erosion. Yields of barley on land broken from grass sod the previous year usually decrease with a delay in breaking beyond July 1st. This effect can be partially overcome by the use of high rates of nitrogen fertilizer.

In the fall of the fallow year, appropriate soil samples

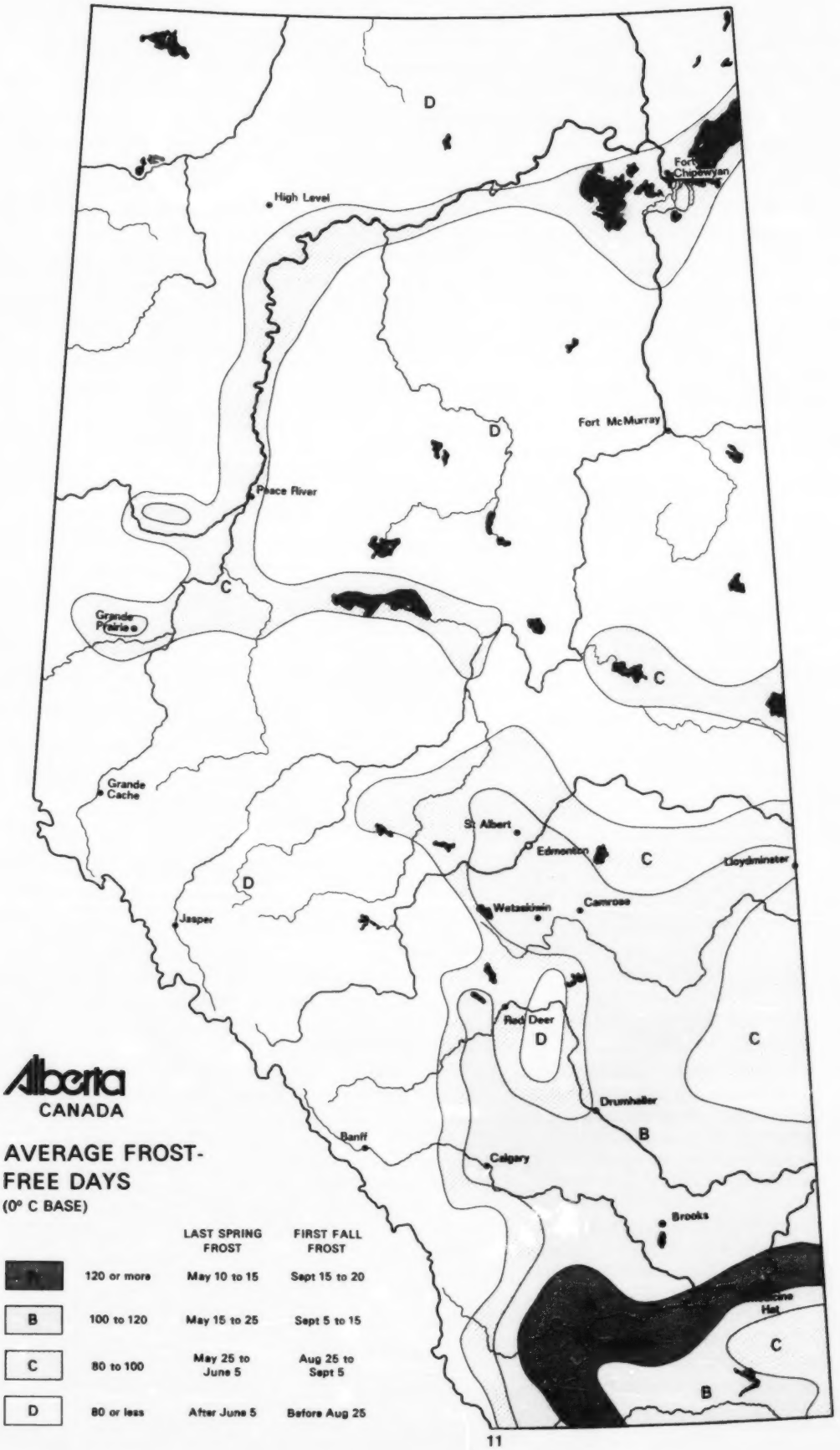

FIGURE 5.
Map showing average number of frost free days in Alberta.

should be taken from all fields, in all areas, to determine fertilizer requirements for the intended barley crop. (See page 13 — 'Fertilizer Requirements of Barley').

Spring tillage of fallow should begin soon after the soils thaw or when weed growth appears. Early tillage often helps to dry wet surface soils and allows them to warm. Early cultivation with a properly adjusted disker and packer, or heavy duty cultivator and rod-weeder, or cultivator and harrow, generally provides good weed control and moisture conservation. Tillage with these implements is satisfactory for preparing a suitable seedbed for barley on fallow.

A good seedbed should be worked to a depth of about 5-8 cm (2-3 in.), but the soil should be left firm to allow for shallow seed placement.

In some areas, on "droughty soils", or where soil moisture is readily lost through tillage, fallows may be tilled and seeded simultaneously, with a disker-seeder followed by packers or harrows. In such cases, no pre-seeding spring tillage for weed control is done, but postemergence weed control with herbicides can be expected. (See 'Seedbed Preparation' on page 12).

Barley Production on Stubble Land

Fall Operations — Land preparation begins during harvest of the previous crop. Cereal and oilseed crops should be harvested high enough to leave erect standing stubble to catch snow and to protect the soil against wind and water erosion, particularly in southern and east-central Alberta. In central and northern areas, if practical, shorter stubble that will hold less snow may be left as an aid in drying fields in early spring. Unless straw and chaff is to be baled and removed for feed or bedding, combines should be equipped with efficient straw choppers and spreaders as an aid to subsequent tillage and seeding.

Before freeze-up, appropriate soil samples should be taken from all fields to be cropped the following year, to aid the farmer in determining fertilizer requirements for the intended crop. Where soil tests indicate a need for nitrogen fertilizer, anhydrous ammonia may be shanked or knifed in when soil temperatures, at the 10 cm depth, are less than about 10° C.

Apply appropriate herbicides to control susceptible weeds such as Canada thistle and wild oats.

Where crop residue is excessively heavy, i.e. after a 4 t/ha crop (about 75 bu/ac) if harvest was early, fall tillage of stubble with a heavy duty cultivator will help to reduce trash cover and may facilitate seedbed preparation in the spring. Excessively heavy trash may reduce yields of barley unless they are adequately fertilized with nitrogen and phosphorus. Shallow cultivation, done shortly after harvest, covers weed seeds and scattered grain, and promotes fall germination of such seeds. Deep cultivation tends to bury weed seeds and aggravates the problem posed by dormancy in wild oats and other weeds which germinate later, when subsequent tillage lifts them near the soil surface. Excessively deep cultivation also allows for loss of critical soil moisture in areas of limited precipitation.

Deep tillage to fracture real or imaginary mechanical or chemical hardpans is seldom necessary on any but some solonetzic soils in Alberta. Winter frosts will generally fracture any consolidated soil masses in most other agricultural soils.

Crop stubble should never be burned. Burning reduces soil organic matter, damages soil structure and reduces plant nutrient availability. Initially, yields of cereals grown on burned stubble land may be increased slightly, but repeated burning will reduce yields.

The producer survey indicated that top farmers do as much of their preseeding work in the fall as possible. For example, more top producers applied nitrogen (65%) and wild oat herbicide (15%) in the fall than producers in the low yield group (25% and 5% respectively). Possible reasons for this are:

1. **Time saved facilitates earlier spring seeding.**
2. **Fewer soil drying operations are needed in the spring.**
3. **Cost of nitrogen is often lower in the fall than in the spring.**
4. **Availability of product and machinery.**

These advantages must be balanced against:

1. **The producer's cash flow situation in the fall.**
2. **Possible loss of product (nitrogen and herbicide) over the winter**
3. **The inability to adjust planting intentions owing to changing market conditions.**

Spring Operations — Tillage should normally begin as soon as weed and volunteer grain growth occurs. In west central and northern Alberta some producers till the land as early as soil moisture will allow, to try and warm the soil and stimulate weed seed germination.

Initial shallow tillage with disc-type implements will incorporate about 50% of the surface plant residue, and sweep or blade cultivators, followed by packers or harrows, about 10-15% of the surface residue. Either will provide good weed control under reasonably dry weather conditions.

Where soil moisture is abundant, tillage must invert or bury weed seedlings to obtain reasonable control. Under such conditions, superficial tillage may merely transplant weed seedlings.

Where wild oats are a major problem, secondary tillage, and hence, seeding, may have to be delayed to allow for wild oat emergence unless appropriate herbicides have been, or are to be, used. Delayed seeding to control wild oats is a rather inefficient and costly method considering the availability and price of today's wild oat herbicides. Delayed seeding is therefore a very questionable economic weed control procedure.

Granular nitrogen fertilizers may be banded or broadcast, on stubble fields, and incorporated before seeding.

Seedbed Preparation

Barley will tolerate a poorly prepared seedbed more

successfully than most crops. However, if soil moisture is kept optimal at all times, few crops respond as well as barley, in terms of increased yields, to a well-planned, carefully prepared seedbed.

Final spring tillage, on either fallow or stubble land, may be done with either well-adjusted disc or cultivator type implements, provided they are operated shallowly and are followed by subsurface rolling packers, rod-weeders, or harrows to firm the loosened soil. Seedbeds must be firm. Loose seedbeds dry out. Heel marks should barely be visible, and you should not sink deeper than the thickness of the sole on a normal workboot in a well-compacted properly prepared seedbed.

Where barley is to be grown under a no-till system, final seedbed preparation consists of a preseeding application of an appropriate herbicide to control weeds. The soil is not tilled or disturbed in any manner.

A good seedbed will be reasonably level, free of large dry surface clods, firm to a 10 cm depth, and be moist throughout its depth. It may have a moderate amount of semi-rotted plant residue uniformly scattered over its surface and throughout its depth to provide protection from erosion.

Results from the survey of barley producers clearly showed that the top producers paid close attention to their spring tillage and seedbed preparation. The majority of top producers had:

1. **A firm seedbed.**
2. **Fewer trips over the land prior to seeding.**
3. **Moisture to within 1.25 cm (0.5 in.) of the surface.**
4. **Incorporated a soil residual wild oat herbicide (fall or spring).**
5. **When asked to rate their seedbed, 90% of the top yield group felt they had achieved a very good to excellent seedbed, compared with only 60% of the low yield group.**

When asked their tillage practices, 90% of the top group used conventional tillage, 10% minimal tillage, and none used zero tillage.

Fertilizer Requirements of Barley

The total amount of plant nutrients removed from the soil by barley depends on the yield of the crop — the greater the yield, the greater the amount removed.

Based on equal seed yields per unit area, whole barley plants extract about the same combined quantities of nitrogen (N), phosphorus (P_2O_5), potassium (K_2O) and sulphur (S) from the soil as does wheat and oats, but considerably less than canola. However, where only the seed is removed, and all straw is left on the field, barley removes slightly more nutrients from the soil than oats but less than wheat or canola (see Table 6).

TABLE 6 — NUTRIENTS USED BY CROPS*
(kilogram per hectare)

Crop	Crop Part	N	P_2O_5	K_2O	S
Wheat	Seed	79	32	21	5
(3225 kg/ha or	Straw	32	7	64	8
48 bu/ac)	Total	111	39	85	13
Barley	Seed	65	24	22	5
(3225 kg/ha or	Straw	34	9	73	8
60 bu/ac)	Total	99	33	95	13
Oats	Seed	58	24	17	8
(3225 kg/ha or	Straw	40	15	70	10
84 bu/ac)	Total	98	39	87	18
Canola	Seed	120	57	29	21
(3225 kg/ha or	Straw	70	26	121	17
57 bu/ac)	Total	190	83	150	38

(To convert kg/ha into lb/ac, multiply by 0.89)

Note: Canola yield is extremely high, but in order to make the comparison, it was left at the same weight as the other grains.

*Source: Western Canada Fertilizer Association.

Soil Tests And Fertilizer Recommendations

It is impossible to provide a meaningful and precise fertilizer recommendation for each individual farm in this publication. Fertilizer applications should reflect differences in nutrient status of individual fields, soil moisture conditions, management practices, current fertilizer costs and availability, expected growing season precipitation, as well as crop or grain prices. Such precise recommendations can be developed and sent to producers who use current soil-test and research results.

To determine the nutrient deficiencies in a soil, appropriate soil samples should be taken annually. Samples should be sent to a reputable laboratory for analysis. From the results obtained, a trained agronomist will be able to recommend the kind and amount of fertilizer that should be applied to the soil to produce a good crop of barley of a desired quality.

Soils intended for barley production should be sampled after October 1st, when soil temperatures are below 10° C, but before freeze-up. Fields may also be sampled in early spring but time is often limited for completing soil tests and for obtaining the required fertilizers.

Fertilizer Application Depends On End Use Of Barley

Few crops respond as well or as readily to applied fertilizers as does barley. A fertilizer management program that will optimize not only plant and grain yield, but also grain quality, must be the objective of all good producers. The kind and amount of fertilizer applied should be governed by the intended end use for the barley. Barley may be used for silage and high moisture grain, dry-feed grain, or for malting.

Silage and High Moisture Grain

Where barley is to be harvested as silage, the grower must adjust his fertilizer program to produce the maximum amount of plant material. For high moisture grain, short straw and high grain yield is desirable. Usually such crops require some phosphorus, as well as heavy applications of nitrogen fertilizer, which may delay maturity. On selected soils, some sulfur and potassium may also be required.

Dry-Feed Barley

High yields of excellent quality feed grain are most readily produced on soils that are well supplied, either naturally or through applied fertilizer, with all of the essential plant nutrients. The nutrients must be supplied in a balanced form so that none will limit growth. Yield will be determined by the most limiting factor of growth. Figure 6 gives an example of expected yield increase in central Alberta when additional units of nitrogen are applied and normal rainfall is received. Figure 7 gives the expected yield increase expected from additional units of phosphorus.

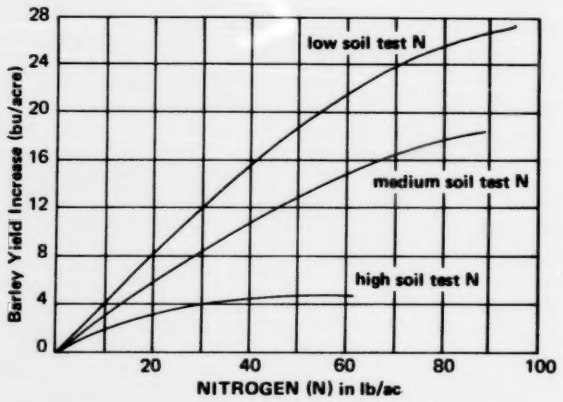

FIGURE 6. Graph showing expected yield increases with nitrogen fertilizer use in central Alberta.

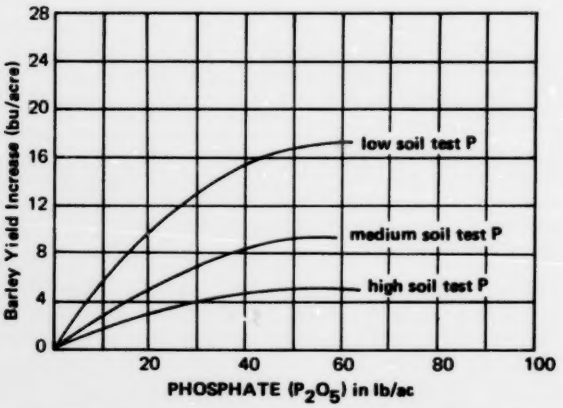

FIGURE 7. Graph showing expected yield increases with phosphorous fertilizer use in central Alberta.

Malting Barley

Growers of malting barley must obtain high yields of well-matured grain of desired quality. The grain must be relatively low in protein content and high in carbohydrates. Growers must be prepared to fertilize adequately with phosphates and other needed nutrients but must not supply an excess of nitrogen. There is less chance of providing an excessive supply of nitrogen to an otherwise properly nourished healthy crop that will produce high yields, than to an undernourished crop which usually produces mediocre or low yields.

Did You Know That:

- Low soil moisture restricts the benefits of applied nitrogen fertilizers on barley yields, but the full effect of favorable moisture conditions cannot be realized until adequate nitrogen has been provided to the barley.
- Maintaining a good supply of available phosphorus to a barley crop is a means of protecting that crop against the adverse effects of above- or below- optimum soil temperatures.
- Root rot is generally less severe in barley that is well supplied with available phosphorus and nitrogen than in inadequately fertilized barley.
- Barley plants continue to use available nitrogen even after the requirements for yield are fulfilled, and as a result, grain protein increases.
- Application of excessive amounts of nitrogen fertilizer will generally produce barley of poor or unacceptable malting quality.
- The application of sulfur to sulfur-deficient soils results in a more efficient utilization of applied nitrogen and phosphate fertilizer and advances maturity.
- Applied nitrogen fertilizer may stimulate the growth of wild oat seedlings almost as much as it does that of barley, so be prepared to control those wild oats.
- Barley usually responds better to applied nitrogen fertilizer when there is also enough available phosphorus present, and vice versa. A proper balance needs to be maintained.
- Potassium is important for straw strength and proper levels will help reduce lodging.
- It is important to have adequate phosphorus close to the germinating seed to be readily utilized, as a large amount of the phosphorus intake occurs in the very early stages of growth.
- 3-6 days earlier maturity can be obtained in soils with proper levels of all nutrients, especially phosphorus.

The survey results showed that:

(1) The greatest number of top producers used 84 kg/ha (75 lb/ac) nitrogen and 39 kg/ha (35 lb/ac) phosphorus, and the low producers used 62 kg/ha (55 lb/ac) nitrogen and 28 kg/ha (25 lb/ac) of phosphorus. See Figure 8 and Figure 9.

(2) The top producers were more aware of their soil condition, i.e. fertility level, pH, and organic matter content than the low producers. With this information, the top producer could then

determine how much and what nutrients to apply to optimize yield.

(3) Seventy-five percent of the top farmers utilized the cheapest source of nitrogen (anhydrous) and 65% applied it in the fall, whereas only 45% of the low group of farmers used anhydrous ammonia and 25% applied it in the fall. See page 12 for pros and cons of fall application.

(4) Only a small number of producers used potassium or sulfur.

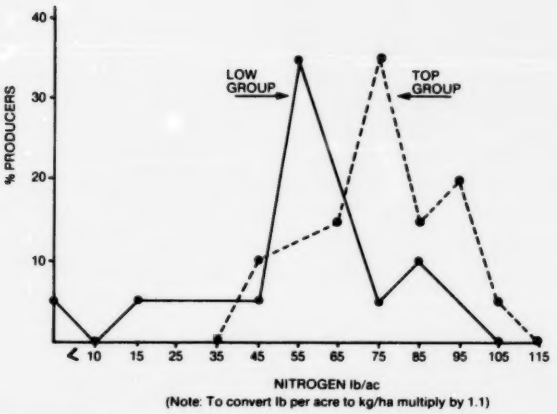

FIGURE 8. Survey results showing different use of nitrogen fertilizer by the top group of producers and the low group.

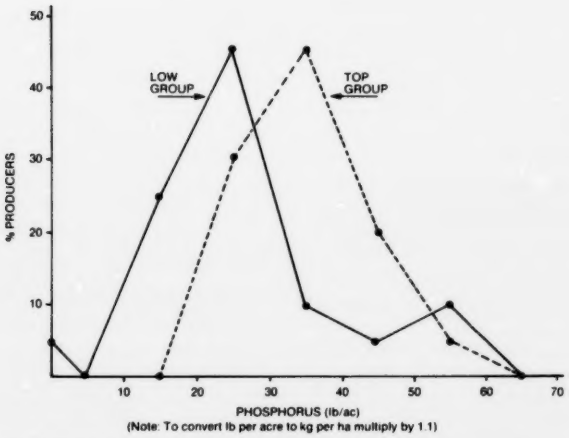

FIGURE 9. Survey results showing different use of phosphorus fertilizer by the top group of producers and the low group.

Variety And Seed Selection

Variety Selection — A grower should choose a variety and try to obtain seed during the fall and winter. Early arrangements are particularly important when changing to a new variety, as seed supplies of newly licensed varieties are usually limited. New varieties are appearing more frequently than ever before, and farmers should be on the lookout for new types that would be particularly suitable for their farm. For example, in 1982 alone, it is likely that Scout, Empress, Abee, Leduc and Diamond barley varieties will be licensed.

The variety chosen will depend on area and intended use of the crop. The varieties available in Alberta in 1982, and their relative performance in the main production areas are shown in Appendix 1. The production areas illustrated are very large and cover a wide range of soil and climatic conditions. While relative yields given reflect the average for a whole production area, they frequently do not apply to particular locations in the area. A producer should consult his district agriculturist for information from the regional varieties testing program on relative yields in his own locality. Regional variety testing has been expanded, and there are now 32 test locations in Alberta. These do not cover all crop districts in the province, but data from one or two locations may be more pertinent to an individual grower than the average results.

Whether the crop will be used for silage, high moisture grain, or dry feed grain should not affect choice of variety; yield of grain is very closely correlated with total dry matter yield among our better varieties. Also among these better varieties, the weight of dry grain versus the weight of dry straw is approximately equal. From this information we can estimate the yield of straw or total plant harvest (dry basis) once the grain yield has been calculated. For example, if the field of barley was judged to yield about 3,233 kg/ha (60 bu/ac) then the approximate plant material weight would be 3,233 kg/ha (1.44 tons/acre) dry basis. For a silage yield estimate, if the silage was to be harvested at 60% moisture, then:

Let X = yield of silage at 60% moisture.
100 - 60 = 40% dry matter.
$0.4X$ = (3,233 kg/ha + 3,233 kg/ha)
$X = \frac{6{,}466}{.4}$ = 16,165 kg/ha
16,165 kg/ha = 16.165 tonnes/ha (7.2 tons/acre)

In the six-row area, and under irrigation, the most productive are the six-rowed feed varieties Klondike, Johnston and Galt, even when used for silage or threshed as high moisture grain. Yields will be higher when a crop is harvested as high moisture grain rather than as dry grain, probably as a result of lower harvesting losses. This is more pronounced in the six-rowed varieties, in which the lateral kernels are smaller and more easily lost in dry threshing.

Important production factors such as maturity, lodging and disease resistance should always be considered when selecting a variety. For example, lodging may be a problem with Johnston, resulting in lowered yields and increased difficulty and expense in harvesting, offsetting its genetically determined yield advantage.

Among the licensed varieties grown in Alberta there are no important differences in quality for use as feed.

Contrary to expectations, our feed varieties are not inherently high in protein. In fact they tend to be slightly lower in protein content than malting varieties because of higher yields which are associated with higher proportions of carbohydrates in the kernels. The protein content of all varieties, both feed and malting, will vary widely, depending on growing conditions. Stresses such as drought, lodging, and disease will increase protein content, as will excessive nitrogen fertilizer. Optimum growing conditions will produce a maximum yield of plump kernels with a high proportion of carbohydrates and a protein content of 10-12% — a desirable range for feeding ruminant animals, as well as for malting.

The long-term average protein content in Alberta barley is 12.4% dry basis. Protein content in any one year ranges from 8% to over 18%. Protein levels of barley are generally higher in southern crop districts than in the north.

Some producers prefer the straw of some varieties over that of others. These preferences seem to depend on palatability rather than nutritional quality. Two extensive surveys were conducted with farmers to determine what varieties had the best straw for feed. The results from both surveys were the same: that no particular variety was better than any of the others. The preference varied with the farmer answering the question.

Table 7 shows the analysis of barley straw by variety for a 10-year period. Considering the many variables that may occur, such as the degree of weathering from year to year, stage of swathing, etc., the figures should not be looked upon as significantly different. They are given as an indication of the barley straw quality that may be expected by the producer.

TABLE 7 — ANALYSIS OF BARLEY STRAW BY VARIETY, 1972 TO 1982

Dry Matter Basis*

Variety	Avg. % Protein	Avg. % Fiber	Avg. % Calcium	Avg. % Phosphorus	No. of Samples
Betzes	4.78	46.3	0.43	0.08	48
Klages	5.28	48.7	0.36	0.09	11
Galt	4.25	49.8	0.43	0.09	26
Bonanza	4.43	52.4	0.43	0.11	58
Conquest	5.44	45.8	0.49	0.14	18
Klondike	6.18	50.8	0.48	0.13	12
Avg. All Varieties	5.06	49.0	0.44	0.11	

*Source: Alberta Agriculture Soil & Feed Testing Laboratory.

The herbicide to be used may restrict variety selection. Some varieties are more subject to damage by herbicides than others. For example, "Hoe-Grass" is not recommended for use on crops of Betzes and Klages.

If the crop is intended for the malting market, the choice is limited to the selection of an acceptable malting variety. Preference by maltsters between six-rowed varieties is not a large factor. In the larger two-row market, Klages quality is preferred. Unfortunately, Klages is not well adapted to the major two-row barley growing areas of Alberta, and risks in its production are higher than for other two-rowed varieties eligible for CW grades. Klages is rather late maturing, lacks tolerance to drought and shattering, and is very susceptible to sprouting if subjected to wet weather during harvest.

Seed Selection — A grower may buy seed or he may prefer to use his own. If he buys seed, he should normally buy pedigreed seed. This guarantees that the variety is as represented, and also guarantees minimum standards of purity, germination and freedom from weeds and disease. Furthermore, he avoids the expense and trouble of seed cleaning and can deliver an equivalent amount of commercial grain on his quota.

If a grower knows that his seed is pure, sound, and free from disease, he may choose to use his own seed. It will be cheaper and there will be no chance of introducing new weeds or diseases. Seed of a variety will remain pure indefinitely if not mixed with other varieties, as barley is self-pollinated. Volunteer barley harvested with the crop contaminates otherwise good seed, and some advantages of the new variety are thereby lost.

The survey results indicate that top producers:

	% Low Group	% Top Group
1. Used the newest varieties.	20	60
2. Seeded feed varieties.	20	70
3. Used pedigreed seed.	25	60

Seed Treatment — There is little advantage in giving chemical fungicide treatment to barley seed that is sound and disease free. However, if the seed is known to be infected with smut, it should be treated. If a smut-susceptible variety is grown and the presence of smut is uncertain, it may be wise to treat home-grown seed at 2-3 year intervals. If wireworms may be a problem, such as on new breaking of grass, or in a field where there was previous damage, a seed dressing containing lindane should be applied.

Seed dressings are available that contain fungicides, or insecticides, or a combination of both, for control of both disease and insects. They come as dusts, liquids, or wettable powders. They can be applied by seed-treating machines or applicators, or in the drill box with the seed at seeding time.

A uniform application of the seed dressing is required for best results. Treatment may be applied some time in advance of seeding without injury to the seed. However, it is best to treat seed at or near seeding time, which will help to prevent unwanted surplus of treated seed and possible contamination of other grain. Treated seed is poisonous. It should not be fed to animals, exposed to wildlife, or sold for use other than as seed. Directions for use should be followed exactly and the precautions heeded.

Time of Seeding — Early seeding usually results in maximum yields of barley. Early seeding ensures efficient use of available soil moisture, allows the crop to escape

damage by the most serious diseases and the worst effects of mid-summer heat and drought. The crop can also take advantage of the longer spring days. Each barley leaf can be envisioned as a small production factory. The factory's work day is equal to the sunlight periods. The more factories you have working by our longest daylight pericds, the greater will be the production.

Barley should be sown as soon as soil temperature, at the depth of seeding, is warm enough for reasonably rapid germination. Soil temperatures are normally measured twice a day, morning and afternoon, and an average of the two readings used. Barley will germinate at 3-5° C, but will emerge faster at temperatures of 5-10° C. Higher soil temperatures will encourage faster germination and emergence, but occur later in the spring when reduced tillering and lower yields can be expected. Soil temperatures in Alberta are usually best in the period from April 20 to May 15, depending on location and season, (See page 26 for Frost Implications).

Occasionally growers will seed in the late fall just before freeze-up, or in the late winter during an unusual mild period. This practice is seldom advantageous and usually results in lower yields. In most areas and seasons, the hazards of late fall or late winter seeding outweigh the potential advantages.

When barley is sown in early May, there is still a possibility of cold and wet spring weather after seeding. There should be no adverse affects if sound seed was planted. If the seed had been weathered or diseased and was untreated, reduced stands and lower yields can be expected. Proper seed treatment of such seed will usually prevent damage.

Before the advent of selective herbicides, seeding was often delayed to facilitate annual weed control. This practice has been abandoned by most growers in favor of control by herbicides. However, a grower may encounter situations, such as very wet or very dry spring weather, when seeding must be delayed. Barley can be sown later than wheat or oats and still mature before fall frosts. In southern Alberta it will often mature when sown as late as June 20th, although yield and quality are reduced. In central Alberta, seeding after June 10th is hazardous, and in the Peace River area, seeding much after June 1st often results in loss of the crop by fall frosts.

The date at which the crop will mature is delayed by late seeding. However, up to a certain time, which varies with latitude, the number of days from seeding to maturity is reduced. The crop can still mature during the fairly long days of late summer and early fall. With very late seeding the crop encounters the short days of late fall during the maturation period and the number of days from seeding to harvest increases. Therefore, the shorter fall days preclude seeding beyond early June in northern areas, June 10th in central Alberta and June 20th in the south.

Contrary to expectations, it is not advisable to use an early maturing variety for delayed seeding. Varietal differences in maturity are compressed by late seeding, and a relatively large difference in maturity between two varieties in August is much less a month later. Usually, the best varieties in an area are the best for late seeding. There are some indications that Conquest, Klondike, and Galt suffer less yield depression from late seeding than most others. Klages and Olli are among the poorest for late seeding.

Producer survey results showed that 85% of the top producers were seeding their barley before May 23rd, whereas only 65% of the low group seeded before May 23rd. See page 26 for frost implications with early seeding.

Seeding Equipment

Barley can be seeded satisfactorily with a wide range of equipment. The seeder selected must open a furrow to sufficient moisture, accurately meter seed into each run, place the seed at a uniform depth, cover the seed with soil and pack it around the seed.

Research work has indicated that there is no significant difference in final yield caused by the commonly used seeders, provided they are properly adjusted. Some commonly used seeders are:

- Press wheel drills with disc openers.
- Press wheel drills with hoe openers.
- One-way disker seeders.
- End-wheel grain drills.
- Cultivator and blade seeders.
- Air seeders with hoe openers.

Some drills may perform more satisfactorily than others on trashy fields, because of their high frames which provide clearance for trash movement. Some have furrow openers arranged in widely-spaced gangs that seldom plug with trash. Drills designed to operate under extremely trashy conditions, or as "no-till' drills, may have a set of coulters positioned ahead of each furrow opener to cut through the trash. Very narrow hoe-openers and disc-type openers will often penetrate compact seedbeds better than wide sweep-type openers.

From the producer survey, the majority (approximately 65%) in both the top and low group were using a double disc press drill to seed. The next most popular (17%) machine for seeding was the hoe press drill. There was no significant difference between the groups versus the machines used to seed. Fifty percent of the farmers in the top group, versus only 10% of the low group, had harrows attached to their seeder. Approximately 70% of the farmers in both groups harrowed a few days after the seeding operation. In almost every case (83%), a fertilizer attachment was affixed to the drill through which phosphorus was applied during seeding.

Seeding Depth

Barley should be seeded into moist soil as shallowly as possible, and normally not more than 5 cm (2 in.) deep. Barley should not be seeded deeper than 7.6 cm (3 in.) where surface soils are dry. If sufficient moisture is not available at the 7.6 cm (3 in.) depth, then it may be best to

seed to a normal depth and wait for rain. Deep seeding retards germination, reduces emergence and may result in reduced seedling vigor with increased disease levels. Barley is more sensitve to deep seeding than wheat or oats. Seeding at depths less than 2 cm may place the seed in soil that is too dry to allow for rapid germination and sustained seedling growth. A recent study showed that seeding Bonanza and Melvin barley at 5, 8 and 10 centimetres depth decreased emergence by 20% and decreased grain yield by 10% for each increase in seeding depth. The severity of common root rot increased by 40%.

Seeding barley by aircraft onto very wet or snow-covered fields is not recommended because it is seldom possible to cover the seed adequately, or soon enough by harrowing or disking, to avoid losses. Exposed seed is damaged by weather and is eaten by birds.

Seeding Rate

The correct seeding rate for barley depends on the area of production, the variety of seed, and on the intended end-use for the crop.

Seeding rates should generally be slightly lower in areas of limited rainfall than where moisture is plentiful throughout the growing season.

Barley varieties with very large, heavy seeds should be sown at slightly higher rates than those varieties that have smaller, light-weight kernels.

Barley that is to be grown as a companion crop with forages or with peas for fodder should be seeded at about half the rate normally used for grain production.

Table 8 provides some suggested rates of seeding for the main soil zones of Alberta.

TABLE 8 — SUGGESTED SEEDING RATES

Soil Zone	Seeding Rates kg/Ha	lb/ac
Brown	40-60	35-54
Dark Brown	55-70	50-62
Thin Black & Black	60-80	54-70
Grey Wooded	70-100	62-90

It is better to plant a little on the thin side than to plant too much seed. The lightest weight kernels are usually produced from barley that is seeded at the heaviest rates and vice versa. Growers who seek to increase their supplies of rare or new seed that is in limited supply, should sow thinly (25-30 kg/ha (22-28 lb/ac)), to obtain maximum amounts of seed.

Increasing the seeding rate is often used to compensate for poorer germinating seed. This is not a good practice. It is better to purchase new seed with good germination, as poor germinating grain is usually unthrifty and possibly diseased.

Row Spacing

Where machines are used that place the seed in rows, highest yields of barley are produced from rows spaced 15-20 cm (6 to 8 inches) apart. Most commercial seed drills used in Alberta have furrow openers spaced 15, 18 or 23 cm apart. Weed growth is often more abundant in rows spaced more than 23 cm apart than in narrower rows. Swath support becomes a problem as row width is increased.

Post Seeding Operations

Usually a harrowing or combination harrow-packing operation is advantageous. This operation not only preserves soil moisture and increases seed-soil contact, but helps level and smooth the land surface so that subsequent spraying and fall field operations are easier.

Ninety percent of the top producers did a harrowing operation after seeding versus only 70 percent of the low-yield group.

Physiology

Now that the seed is in the ground and germination is starting, an understanding of what is happening to the plant is essential for making management decisions. How the parts of the barley plant function and the processes that go on within the plant are called its physiology. Barley is a member of the grass family and is one of the "bunch" grasses. The bunch habit results from the development of buds near the base of the main stem that produce additional stems called tillers. Each plant develops two separate root systems. Primary roots develop from the seed and grow quickly, ensuring a moisture supply to the young plant even when the soil near the surface dries. Later, a secondary root system develops from a crown that forms just below the soil surface, which is the source of tillers as well as crown roots. The primary roots are joined to the crown by a sub-crown internode, a slender section of stem that carries moisture and nutrients to the developing plant, maintaining it until leaves and crown roots are well established.

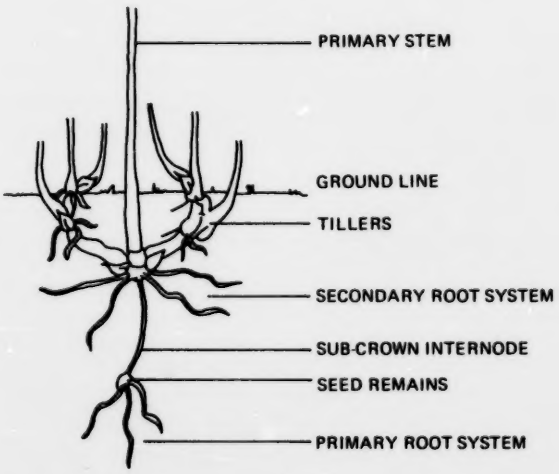

FIGURE 10. Diagram showing parts of a barley plant.

The seedling stage is a critical period of growth and damage to the sub-crown internode from diseases or insects during this stage will weaken or kill the young plant. The length of this internode is determined by sowing depth, and the longer the internode, the greater the probability of damage from disease or insects. Shallow seeding into a firm, moist seedbed assures a short sub-crown internode and promotes the growth of healthy young plants.

The crown root system is responsible for supplying most of the plant's moisture and nutrient requirements. During unusually dry seasons, or with delayed seeding, the surface soil can become dry. If so, few or no tillers and crown roots develop. The main stems must produce heads and grain from moisture and nutrients supplied by the primary roots. When this happens, yields are low, even if the soil moisture is adequate when the heads are filling.

The Feekes scale of growth stages illustrated in Figure 11 was developed for wheat but applies equally to barley up to the boot stage. In a typical season over much of Alberta the crop will be sown in early May. Completion of stage 1 will require about 6-12 days, and stages 2-5 an additional 5 or 6 weeks. The buds that develop into the above-ground plant parts form at the growing point during the late seedling stage. Therefore, plant development and potential yield is determined very early, i.e. by the fourth leaf stage. Damage to these buds during the seedling stage prevents normal growth, and weak seedlings cannot grow into healthy plants even under ideal growing conditions. However, the growing point remains below the soil surface until tillering is nearly complete. This delayed emergence of the growing point protects it from damage by frost, wind, hail, and some insects, and allows plant recovery if the leaves are damaged. Damage to leaf tissue at this early stage has little or no direct effect on yield, however, some maturity delay is likely.

Stages 6 to 10 proceed very quickly in late June or early July, and flowering in barley takes place in the boot at our latitudes. Grain filling and maturity will be completed during August over most of the province.

The actual time from seeding to maturity will depend on temperature, light, nutrition, moisture and variety. Mid-season varieties like Bonanza and Galt can mature in as few as 80 days, or require as many as 120 days from seeding. They will normally mature in 90-95 days in the south, and about 100-105 days in central and northern areas.

Yield is the product of the following three components:

1. Number of heads per unit area

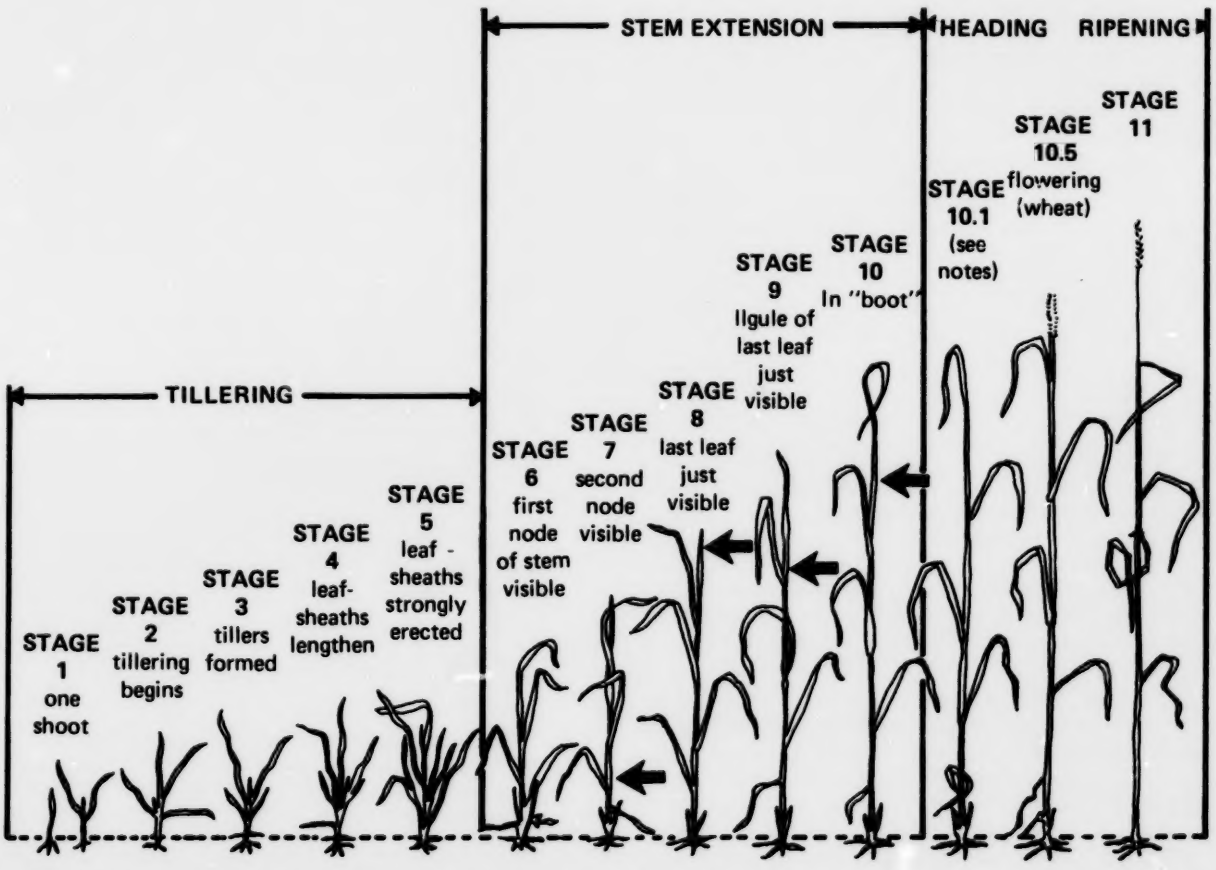
STEM EXTENSION
HEADING
RIPENING
TILLERING
STAGE 1 one shoot
STAGE 2 tillering begins
STAGE 3 tillers formed
STAGE 4 leaf-sheaths lengthen
STAGE 5 leaf - sheaths strongly erected
STAGE 6 first node of stem visible
STAGE 7 second node visible
STAGE 8 last leaf just visible
STAGE 9 ligule of last leaf just visible
STAGE 10 In "boot"
STAGE 10.1 (see notes)
STAGE 10.5 flowering (wheat)
STAGE 11

FIGURE 11. The Feekes scale of growth showing the development stages in a cereal plant.

2. Number of seeds per head
3. Seed size

Under optimum growing conditions each plant will produce a large number of tillers and long heads with plump seeds. Consequently, yield is fairly constant over the range of recommended seeding rates. Thin seeding results in heavy tillering and large heads and seeds. Conversely, thick seeding results in reduced tillering and smaller heads and seeds. Heavy seeding promotes somewhat earlier maturity but may contribute to lodging, and to lower yields where moisture is limited.

Environmental stresses during the growing season can reduce yields by affecting any or all of these components. Effects of stress during the flowering stage are most severe. Even moderate drought during this stage can result in appreciable yield loss.

Weed Control In Barley

Weeds are responsible for serious yield losses in barley and controlling them will usually result in a substantial increase in net income. Weeds compete with barley for light, nutrients and moisture. When these factors are limiting, barley yields will be reduced. The yield reduction will be directly proportional to the weed population in the crop. In many areas of Alberta, yields are still reduced by 15-20% through competition from weeds.

Wild oats constitutes a major weed problem to many barley growers in Alberta. Research on barley in central Alberta shows that yield losses through competition from wild oats may be predicted when the number of wild oat plants present per unit area is known. This is done by applying the equation,

$L = 0.177ax$,

where L is the predicted yield loss (g/m^2)
a is the predicted weed-free yield (g/m^2)
x is the number of wild oat plants per square metre.
(5.38 g/m^2 = 53.8 kg/ha = 1 bu/ac)

Example:

If a field of barley would yield 11.16 g/m^2 (60 bu/ac) with no wild oats present, but it is found to have 30 wild oat plants per square metre by actual count, then the predicted yield loss can be calculated as follows:

$L = 0.117ax$
$a = 11.16$
$x = 30$
$\therefore L = 0.117 \times 11.16 \times 30\ g/m^2$
$L = 39.17\ g/m^2$ (7.3 bu/ac) yield loss.

Weed seeds present in barley grain may be responsible for major dockage and grade losses at market time. Excessive weed growth present in barley harvested for silage may reduce the quality of the fodder and can affect palatability. Malting barley contaminated with excessive numbers of certain weeds will not achieve malting grades. The cost of control must be balanced by the expected increased return to the producer from an increase in crop production, both in the current year and in future years.

There are five fundamental methods of controlling weeds in barley.

Preventive Measures:

- Use weed free seed.
- Use only clean, weed-free machinery and hauling facilities.
- Restrict animal movement from weedy fields to clean fields.
- Handle weedy manure in a manner to eliminate spread of viable weed seeds.
- Where possible control or restrict wind and water movement from weedy to weed-free areas.

Physical Control Measures:

- Tillage that will bury weeds, expose them to frost or drying, or wound them to allow for entry of decay-causing organisms.
- Hand weeding of smaller patches of select weeds.
- Mowing where tillage is impractical.
- Burning weeds prior to maturity.
- Pasturing and grazing to prevent seed formation.
- Mulching small weed patches with clean straw, manure or polyethylene film.

Cultural Control Measures:

- Use crop rotations that may include fallow, forage crops, row crops, or fall-sown cereals, to take advantage of weaknesses in the life cycle of existing weeds and thereby eliminate them.
- Plant competition. Any measure that enhances vigorous crop growth helps to control weeds.
- Adjust timing of cutlural operations. Delayed seeding has traditionally been used to control certain weeds. Today, however, with the herbicides available, delayed seeding is a very doubtful economic practice for controlling weeds. Seeding fall-sown crops in rotation with barley is an effective weed control measure. Crop growth is established before weed growth begins in the spring.

Biological Control Measures:

This technique has not yet been perfected to the point where it has any major value to individual barley producers. Control agents are usually insects or diseases which attack only one specific weed.

Chemical Control Measures:

Many herbicides are available for use on weeds commonly found in barley in Alberta. Most herbicides, currently recommended, are relatively cost-efficient and are the only widely applicable means of controlling weeds in the growing crop.

When herbicides are used as directed, they usually do a good job of controlling a wide range of weeds, though some are extremely specific and control a single species only.

Most, though not all, failures to properly control weeds can be explained by the applicator failing to follow the label directions.

From the survey of farmers in agro-climatic Zone Three shown in Appendix 1, the four most troublesome weeds were Canada thistle, wild oats, hemp nettle and chickweed. This listing was the same for the top and low producers. The differences noted between weed control measures used by top and low producers were:

1. Top producers achieved greater weed control at the seedling stage and throughout the growing season.
2. Top producers were more aware of their weed problems (types and numbers).
3. The top producers achieved better weed control through greater use of broadleaf herbicides, including mixes, and a greater use of wild oat herbicides.
4. Eighty-five percent of the top producers used "Triallate" compared to only 50% of the low group. Thirty percent of the low group relied on post emergence wild oat herbicides, and 20% of the low group used no wild oat control. 100% of the top group used a wild oat herbicide, of which 20% was a post-emergent type. Granular "Triallate" was more popular among the top group than liquid "Triallate".
5. Only 20% of the top group felt that wild oats contributed to yield loss after their herbicide program, compared to 55% in the low group.

Barley Diseases

Major diseases in barley are pathogenic in nature and are caused by fungi, bacteria or viruses. Other diseases are nonpathogenic and are caused by harmful environmental factors such as nutrient deficiencies or adverse weather. Pathogenic diseases are controlled most easily by using resistant varieties, but these are not always available. In some instances, the development of resistant varieties by plant breeders is nearly counterbalanced by development of new races of the pathogen.

Common root rot is the most important disease of barley in Alberta. Annual yield losses for southern and central Alberta, in the latest survey, were estimated at 10%. Spores are present in the soil, germinate and invade plants just below the soil surface, infecting the crown and subcrown internode. Infected plants tend to be stunted or lacking in vigor, and show brown discoloration of roots, stem bases, crown, and lower leaf sheath.

Shallow seeding reduces the risks. Rotating barley or wheat with grass, flax, canola or oats will reduce the number of spores in the soil, and consequently reduce root rot in the following barley crop; however, some spores do remain dormant for 2 or 3 years. None of the varieties available is highly resistant, but our best varieties are either moderately resistant or tolerant. Bonanza is relatively resistant and normally avoids serious damage by common root rot. Galt, on the other hand, is relatively susceptible but is able to tolerate fairly heavy infection without yield loss. Gateway is quite susceptible and may suffer yield losses of 40%.

Barley scald is a leaf disease that spreads and develops best in cool, humid weather frequently experienced in June and early July in the parkland area of Alberta. It can first be recognized by light green oval or lens-shaped spots on the leaves that quickly dry to white areas with brown margins. Yields are affected only when the top two leaves are damaged, as lower leaves do not contribute directly to grain filling. Average yield losses in the most recent survey were estimated at 2.4%, ranging from negligible in census divisions 1 to 3; to 5% in census divisions 11 and 12. Scald can be controlled by rotating barley with other crops because it overwinters on infected leaves.

Net blotch can be recognized by brownish streaks on the leaves that have a network of darker brown lines within them. Net blotch fungus overwinters on the seed or on crop residues in the field. It infects the foliage of the new crop and spreads most rapidly during warm and humid weather. Like scald, it is usually most apparent at heading time and does not reduce yields unless it damages the top two leaves. The latest survey results indicate that net blotch caused an estimated 1.5% yield loss in Alberta, with the heaviest losses in census divisions 5, 6 and 7. It can be controlled by seed treatment and crop rotation.

Barley stripe is a potentially very destructive disease that has been almost unknown in Alberta until very recently, probably because of the relatively high level of resistance in our varieties. Appearance of the disease has coincided with the introduction of the European variety Summit, which is very susceptible. At present, Summit is grown on a very limited area in Alberta, but expansion of this acreage, or introduction of other highly susceptible varieties, could lead to severe losses. The disease is seed borne and no effective commercial seed treatment is currently available.

Smuts are seed borne diseases. Loose smut, covered smut, and false loose smut are widespread in Alberta, but do not have much effect on yield over the province as a whole. Losses in individual fields can be significant and growers should ensure that seed planted is either free from smut, or treated with a recommened fungicide.

False stripe or barley stripe mosaic is a seed borne virus that occurs in Alberta, but has been kept under control. Symptoms closely resemble those of true stripe. The virus has no known vector and must be spread by plant contact. Thus, the only source of the disease is infected seed.

Barley yellow dwarf is caused by an aphid-transmitted virus that frequently causes severe yield losses in California and the northwestern United States. Infected leaves turn golden yellow from the tips downward and infected plants are stunted. The aphids do not overwinter in Alberta so the virus must be re-introduced here each year by wind blown aphids. The disease usually arrives too late to cause much damage. Late-sown spring crops can be severely infected, as well as fall cover crops.

Insects

Damage from insect pests can usually be minimized by cultural practices and proper use of insecticides. Cultural control should be used wherever possible to reduce the need for insecticides. When insecticides are necessary to

prevent loss, they should be applied with caution and only as recommended.

Wireworms are slender, hard-bodied, shiny, yellow worms, the largest about 2.5 cm (one inch long). Eggs are laid by adult beetles in the spring and larvae may remain in the soil for 5 to 10 years before pupating and emerging as adult beetles in early summer. Populations build up slowly but fields remain infested for years if larvae are not controlled. Wireworms feed on germinating seeds and underground parts, shredding the stems but seldom cutting them off. Severe damage results in thin patchy stands. The central leaves die but outer plant leaves often remain green for some time.

Barley is more tolerant to wireworm damage than wheat or rye, but will be damaged when infestations are heavy, such as on new breaking of grassland. Seed treatment will reduce damage in current and in future crops by reducing insect populations. Shallow seeding into moisture and firm packing will effectively prevent damage when populations are low.

Cutworms are fleshy, soft-bodied worms that curl up and remain motionless when disturbed. Fully grown, they are about 3 to 5 cm (1.15 - 2 inches) long. The most common species are the pale western cutworm, most prevalent in grassland areas, and the redbacked cutworm, prevailing mainly in parkland areas. Both feed at night, cutting off plants just at or below the ground surface. Damage is most severe when plants are in the seedling or early tillering stages.

Damage by both species can be controlled by discouraging egg laying. Leaving summerfallow undisturbed during August to mid-September reduces egg laying by pale western cutworm moths which lay at this time into loose and dusty soil. The red-backed cutworm will lay in weedy fallow and weedy patches in crops, therefore, weedy summerfallow in parkland areas should be worked during this period. Young larvae of both species can be starved in the spring by destroying green growth 10-14 days before seeding. Because late seeding will result in lower yields, it is usually preferable to seed during the optimum time and use a chemical control if necessary for cutworm control.

Grasshoppers can damage field crops, although only three of the many species of grasshoppers in Alberta are a threat. All overwinter as eggs that hatch in the spring. Depending on species, eggs may be laid on roadsides or headlands, or scattered throughout stubble fields. Damage is most severe during dry periods in the early stages of crop growth. Relatively cool and moist growing conditions reduce grasshopper feeding and encourage crop growth, allowing the barley to keep ahead of damage. Seeding early and producing a vigorous crop assists in reducing damage.

Forecasts of the expected extent and severity of outbreaks are prepared by Canada Agriculture each year. The forecast is in most farm papers. When grasshoppers first hatch in breeding areas such as roadsides and headlands, they can be controlled by early applications of insecticides to these relatively small areas. Fall tillage helps to destroy eggs by exposing them to predators and the elements.

Aphids seldom inflict economic damage on barley crops in Alberta. Infestations do not normally build up to damaging levels until the crop is nearly mature. Damage occurs most frequently when barley is sown late in the spring or as a cover crop in the fall. If very heavy infestations build up (50 per plant) before heading, chemical control may be justified. Of the many species present, only 3 or 4 are of economic importance.

Barley Thrips have damaged crops in west-central and northern Alberta on rare occasions. Thrips feed on the developing head while it is in the boot stage, and first indication of their presence is the appearance of "white heads" in the field. Yield loss is proportional to the number of damaged heads, but the striking appearance of the white heads in the green crop leads to overestimates of damage. Control is not practical since the damage is complete by the time it is obvious in the field.

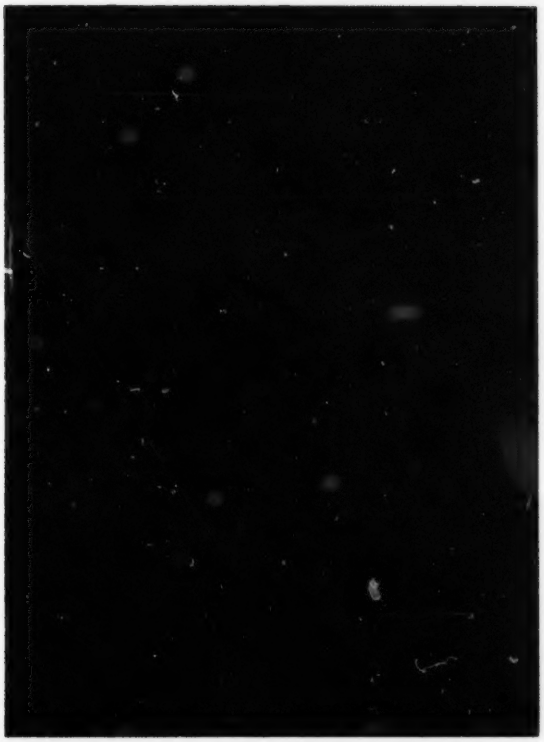

FIGURE 12. Common root rot: seedling blight stage, note root browning.

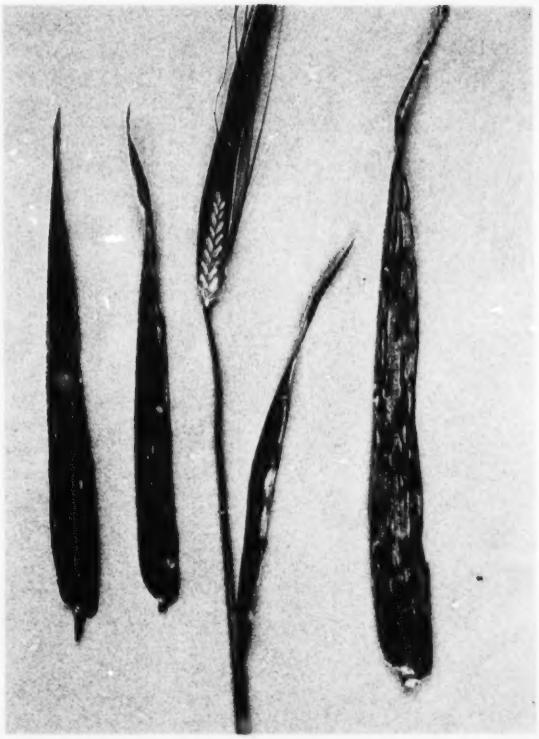

FIGURE 13. Barley scald: scald symptoms on leaves.

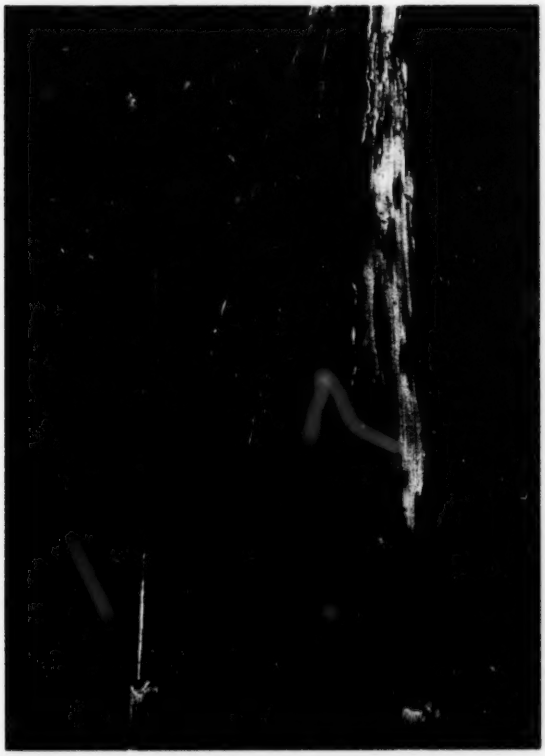

FIGURE 14. Net blotch of barley: note net-like browning.

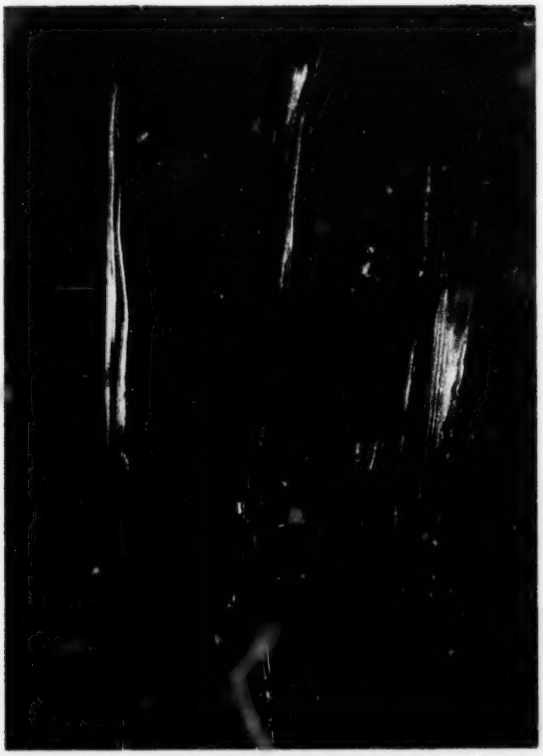

FIGURE 15. Barley stripe on leaves.

FIGURE 16. Barley stripe showing fraying of flag leaves and poorly emerged heads.

FIGURE 17. Barley covered smut, only obvious on heads at maturity.

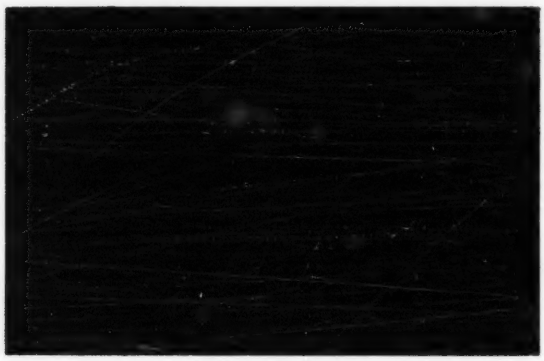

FIGURE 18. Barley loose smut. Healthy head and infected head. Fungus spores released at flowering stage.

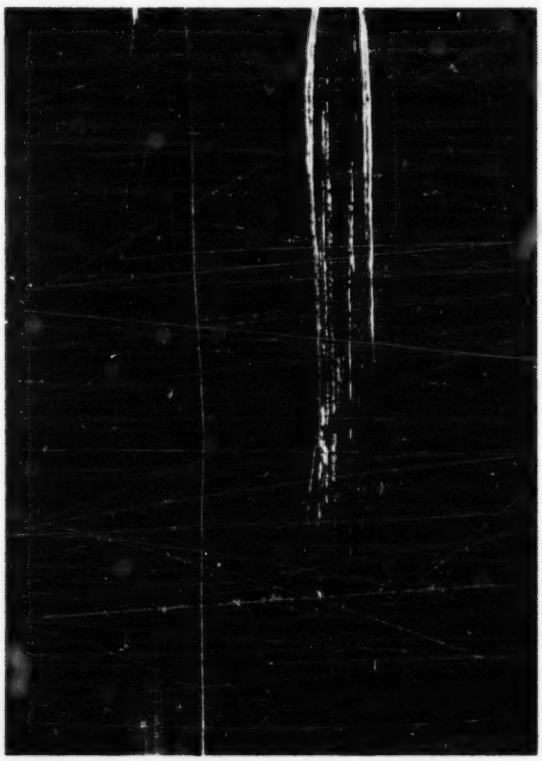

FIGURE 19. False stripe: healthy leaf and leaf with virus symptoms (R).

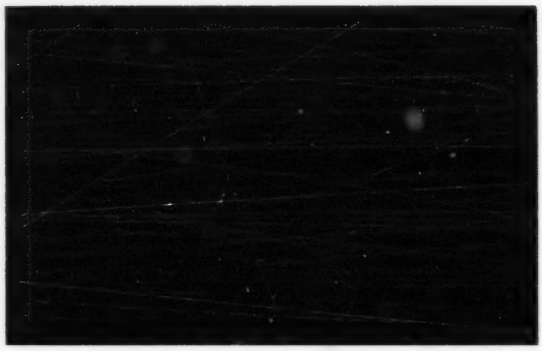

FIGURE 20. Wireworms.

FIGURE 21. Pale western cutworm.

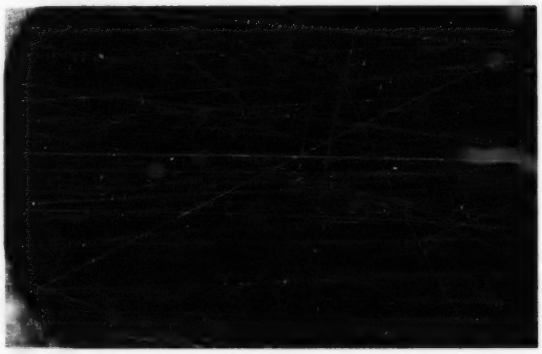

FIGURE 22. Redbacked cutworm.

FIGURE 23. Clearwinged grasshopper adult.

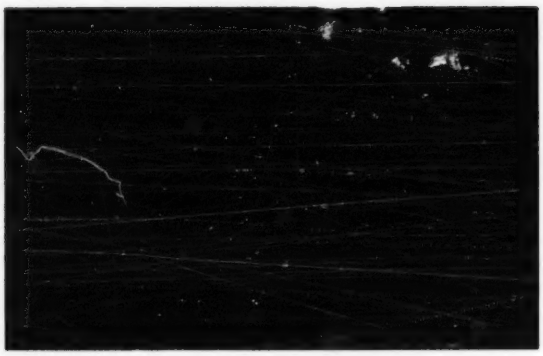

FIGURE 24. Aphids.

FIGURE 25. Barley thrips.

Effects of Hail

A barley crop will recover from severe hail if damaged before the end of the tillering stage. This damage is confined to loss of leaf tissue. The stems and younger leaves will develop nearly normally. There is an adverse effect on yield that increases as the crop develops because of greater loss of leaf tissue.

Hail damage after the stem extension or shooting stage damages the growing points and has a drastic lowering effect on yield. Recovery depends on the growth of new tillers from crown buds. Chances for recovery decrease as the crop develops, and, if a crop is badly hailed after heading, salvage for silage or hay may be the best course of action. The nitrate content of the fodder may be dangerously high for feeding and samples should be analyzed before use. If nitrate content of the hay or silage is too high to be fed safely, it can be mixed with other feed to reduce the average nitrate content. A nitrate level of 0.5 percent in feed is potentially dangerous: 0.75 percent will reduce milk production, 1.5 percent is usually lethal.

Frequent light hailstorms that partially damage a crop will cause more damage in some varieties than in others. Fewer stems are broken by such storms in the two-rowed varieties, Fairfield, Hector and Betzes, than in any of our six-rowed varieties.

Frost Damage

Frost damage to barley can be avoided in most areas of Alberta by seeding early. In areas with short growing seasons, the probability of damage from fall frosts can be reduced by planting early-maturing varieties like Olli, Gateway 63 and Otal.

Late April and early May seeding will occasionally expose the young crop to freezing temperatures while it is in the seedling or tillering stages. However, barley can withstand very low temperatures while it is still in this vegetative stage. Damage will depend on intensity and duration of the freezing period, but a temperature of around -8° C is requred to kill the leaves of seedlings. Early May temperatures are rarely this low, and, even when the young leaves are damaged, recovery is usually complete because the growing point is protected from damage by being below the soil surface. Susceptibility to frost damage increases with increasing plant development, but the probability of severe frost decreases as the season advances. Freezing temperatures will very rarely occur in June after the crop has started to shoot and the growing points are no longer well protected. Exposure to frost at this stage will kill the very tender and immature heads. Recovery for grain production will require regrowth from the crowns. This will delay maturity and lower grain yields. By the onset of flowering, a frost of 0° C to -2° C is sufficient to damage the young florets and result in partial or even complete sterility in the heads. Early seeding or the use of early maturing varieties will not avoid damage from such very late spring frosts. but they happen so rarely that they should not deter one from seeding early.

Barley is most frequently damaged by frost in the fall when the crop is filling or maturing. Symptoms of the damage are seldom obvious as the developing kernels are killed and the leaves are apparently unharmed. The kernels do not develop further after freezing, and yield loss depends directly on the stage of filling, with losses decreasing with advancing maturity.

When a barley crop has filled but has not yet dried and ripened, there is no obvious damage from a killing frost. There is little or no effect on yield and the kernels appear nearly normal. However, frozen grain will not germinate and is useless for seed or malting.

When a crop is frozen at the flowering stage or later, it can be harvested as hay or silage. The sudden stoppage of growth may result in fodder with excessively high nitrate content (0.5% or more), and, as in the case of hailed crops, should be analyzed to determine how safe it is for feed. If the kernels are filled and the grain harvested in the usual way, it is probably safe.

Lodging

Lodging is often caused directly by wind and rain that flatten the standing crop. High soil moisture and nitrogen content both contribute to frequency and severity of lodging. Lodging usually occurs after heading. A crop that lodges early will recover through the formation of "elbow joints" at the lowest stem nodes. The cells on the lower side of the node elongate and force the stem erect. As plants mature the stem cells mature and are no longer capable of elongation to enable plant recovery.

Severe lodging interferes with the transport of nutrients and moisture from the soil, and thus with food storage in the developing kernels. Lodging always results in some yield loss, and if permanent lodging occurs shortly after heading, the yield reduction can be as high as 40%. Yield losses from lodging become smaller as the crop matures, but losses will continue until the kernels are completely filled. Incomplete filling results in disproportionately small kernels whether used for malting or feed, and lowered carbohydrate content will reduce its usefulness for either purpose.

From the survey, the top producers reported more lodging than the low producers. Sixty-five percent of the top producers reported medium to heavy lodging. Only 25% of the same group felt that the effect of this lodging was "medium to heavy" on yield reduction. The yield loss effect from lodging was not as great as the amount of lodging itself.

Lodging resistance was a deciding factor in variety selection to 95% of the top group, and only 75% of the low group.

Over and over again one of the major differences shown between the top farmers and the low group in the survey was that the top farmer paid attention to detail, being aware and using every little advantage he could to come up with the final large yield difference (92% higher yield).

Harvesting Barley

Barley may be harvested at the appropriate stage to provide:

- Whole plant silage.
- Dry fodder.
- High moisture grain.
- Dry grain for feed.
- Dry grain for malt.

Whole Plant Silage

Most varieties of barley may be harvested to provide silage. Harvesting the entire barley plant utilizes the maximum amount of growth produced per unit area. It advances the normal date of harvest about 2 weeks and provides an opportunity to market the crop as fodder rather than as grain. However, the market for silage must be relatively close as transport of high moisture material is quite expensive.

Harvesting for silage should begin when the barley heads are well filled and the grain is in the late soft-dough stage — when it contains 55-60% moisture. Crops that are cut when they contain more than 60% moisture should be allowed to field-wilt to that stage before being chopped and ensiled. Chopped barley that contains 55-60% moisture will form a loose ill-defined ball when it is squeezed in the hand. The ball will fall apart gradually as it is released. It should not be possible to squeeze any appreciable amount of moisture from the ball. Water will usually ooze out of a ball of chopped barley that contains more than 70% of moisture. Plants that contain less than 55% moisture will seldom maintain a proper ball form after being squeezed in the hand.

As the barley crop matures from heading to the soft-dough stage, the amount of dry matter harvested increases at a rate of about 1.12 tonnes/hectare per week (0.50 ton/acre/week). Although the protein content of the plants decreases as they mature, the total protein production per unit area, and the total digestible energy per unit area, peaks when the grain is in the soft-dough stage.

Barley crops that are harvested for silage at the soft-dough stage will yield about 20 tonnes/hectare wet forage (63% moisture) or about 7.3 tonnes/hectare dry matter (9 tons/acre wet, and 3.25 tons/acre dry). Extremely heavy crops grown on well managed irrigated land will yield considerably more forage. Silage barley will yield almost as much as silage corn in most areas of Alberta. However, in southeastern Alberta, where high temperatures often prevail, well managed irrigated silage corn will outyield silage barley by a fair margin.

Barley cut for silage should be handled quickly and carefully and may be stored in sealed silos, conventional tower silos, or horizontal silos. The usual precautions for making high quality silage must be observed. Packing the plant material in the silo to exclude air is imperative. Mixing of additives to chopped barley in the silo, to increase protein content, to promote pickling, or to reduce dry matter losses, is of doubtful value. The relative and absolute values of the various additives that are available should be investigated thoroughly before they are used extensively.

Dry Fodder

Barley may be harvested as an annual forage crop to provide dry fodder. For maximum yields consistent with good quality and acceptable palatability, it should be cut at about late soft-dough stage. More mature plants will yield slightly more fodder, but may be less palatable to livestock.

The crop may be cut with a conventional forage harvester or swather and allowed to field-dry in the swath or windrow. When the swaths are dry (less than 12% moisture), the forage may be chopped, baled, or handled as loose fodder and placed in storage barns or stacks.

In the brown soil zone, irrigated barley generally yields more forage than oats or spring wheat. However, in the black and grey-wooded soil zones, oats will probably outyield barley. Most varieties should yield about 7 to 8 tonnes/hectare (3 to 4 tons/acre) dry matter.

Smooth-awned (beards) or semi-smooth awned varieties may be preferable to the rough-awned varieties as feed, though no serious problems have been encountered by feeding the current varieties of the rough-awned type. To ensure proper nutrition, cattle fed barley forage should also receive about 1% limestone and appropriate amounts of vitamin A. Dry whole-plant barley forage will provide about the same amounts of digestible energy as alfalfa, and slightly more than timothy hay in cattle rations. Alfalfa forage contains more protein than barley forage.

High Moisture Grain

As an optional management practice, or where late-sown grain may fail to mature, or where poor drying conditions prevail at harvest time, barley may be harvested when the grain contains 25-35% moisture. At the present time 30% moisture seems ideal. Such grain is handled, stored and utilized as high moisture feed grain.

High moisture barley is usually combine harvested directly from the standing grain without swathing. The entire crop, including green patches, is harvested. It can usually be harvested about 7 to 10 days earlier than mature dry grain but this will vary from season to season and between localities.

Since slightly immature grain stands more erect than full mature grain, high moisture barley can usually be cut 7-15 cm higher than mature barley.

Harvested high moisture barley is generally handled in large elevators or with frontend loaders because it fails to flow like dry grain. It must be stored in oxygen-excluding silos. The barley may be rolled or stored as whole grain.

Yields of high moisture barley are usually 7 to 10% larger, on a dry matter basis, than those of mature grain, primarily because fewer small, light weight, and cracked kernels are lost in harvest. There is some evidence that six-row varieties yield slightly more high moisture grain than two-row varieties, for the same reason. The higher yields may be due in part to the fact that moist grain will not crack, grind or peel as readily as dry grain, thus cutting losses and increasing yields.

The advantages and disadvantages of harvesting barley as high moisture grain may be:

Advantages

1. Harvest advanced 7 to 10 days
2. Less chance of storm damage to crop
3. Harvest entire crop - no patches left
4. Swathing eliminated
5. More weed seeds harvested and used as feed
6. Short-strawed varieties easier to harvest
7. Increased yield of dry matter
8. Longer post-harvest period to allow for weed growth and control
9. More acceptable as feed, if processed, resulting in earlier gains
10. Provides opportunity to reclaim hailed barley at an earlier date after being damaged
11. Earlier resumption of harvest following wet weather
12. Earlier harvest means greater availability of custom machinery if needed
13. Residual straw may be more palatable to livestock and have higher protein content
14. Alternative market potential
15. No dust in the feed
16. Reduced incidence of bloat and rumenitis

Disadvantages

1. Slower harvesting
2. Greater weight of crop to handle
3. Special handling equipment necessary
4. Special storage necessary
5. Restricted market potential
6. Greater risk of spoilage and loss than with dry grain
7. May be less acceptable as feed unless it is processed

Dry Grain for Feed

Straight Combining — Feed barley should be harvested as soon as the grain contains less than 14.8% moisture. In southern Alberta, where growing seasons are relatively long, and warm dry harvest weather prevails, such mature barley may be combine harvested directly from the standing grain. When kernel moisture content is less than about 14.5% it may be better and more economical to straight combine rather than to swath before harvesting. Severe grain losses through wind shattering can occur in some barley varieties that are allowed to stand and become "dead-ripe". Fluffy, over-ripe barley tends to pile up on the header platform of the combine and enters the feed elevator and cylinder in gobs, rather than in the smoothly flowing ribbon of grain. Fluffy barley is often harvested with less difficulty during early morning and late evening when humidity is high.

Feed barley crops that are excessively weedy should not be straight combined unless all weeds are dry and ripe. Green, moist weed seeds and plant parts, that may be harvested with otherwise ripe, dry barley, may heat in storage and lead to spoilage.

Barley crops with late secondary growth of stems and immature heads should seldom be straight combined. The presence of green colored immature shrunken kernels in other wise good quality grain may lead to reduced market grades. Occasionally, it is possible to cut above the green growth, but generally it is better to swath the entire crop and gain the advantage of the added yield.

In central and northern Alberta, most barley crops must be harvested under less than ideal weather conditions. Crops tend to mature less uniformly and may be damaged by excessive moisture or early frosts. Under such conditions straight combine harvesting is seldom practical or possible so the barley should be swathed, allowed to dry, and then combined.

Swathing Feed Barley — Feed barley can usually be swathed 5 to 10 days before it can be harvested by straight combining. Swathing reduces losses from insects, from shattering, from hail and frost, and eliminates problems associated with harvesting grain with green undergrowth and green kernels.

Barley may be swathed without loss of yield or volume weight as soon as most of the crop has turned from green to light brown or buff color, and the kernels contain less than 40% moisture. Grain intended for seed should contain less than 35% moisture before being swathed. Kernel moisture should be determined with a reliable moisture meter on representative grain samples from the entire field. Kernels that contain about 40% moisture are in the firm dough stage. They can be flattened by squeezing between the thumb and forefinger, but no beads of moisture will appear on the kernel.

At swathing time, some small patches of less mature, slightly green barley will usually be present, but this should also be cut. Some varieties of barley develop a slightly purple or pink color as they mature and ripen for swathing.

Barley should be swathed at a height of 15 to 20 cm (6 to 8 inches) so as to lay a windrow that is light enough to dry readily if rained on and to decrease the combine straw load by leaving as much stubble as possible. However, stubble height in excess of 20 cm may lack the necessary strength to support the swath. The swath should be heavy enough and overlapped sufficiently to feed continuously when it is picked up by the combine. The heads of the grain should be laid under the straw to protect them from bleaching. The width of the windrow should be adjusted to effectively utilize the capacity of the combine that will be used to harvest the crop. To avoid shattering and loss of grain at the cutter bar, the swather's reel speed must be adjusted to the forward speed of the machine.

Combining Swathed Feed Barley — Normally, feed barley swaths can be combine harvested 4 to 7 days after being swathed, but this depends on kernel moisture content at swathing time and prevailing weather conditions. Swathers that are held high on the standing stubble dry most quickly, especially in warm, dry, breezy weather. They should be picked up and threshed as soon as kernel moisture content decreases to 14.8% and safe storage is assured, or slightly higher moisture content and aerated.

Dry Grain for Malt

Maltsters require mature, plump, uniform barley that will germinate vigorously and uniformly. They do not want skinned, cracked or broken kernels. Skinning and breaking occurs when careless or improper harvesting methods are

used. Skinned kernels have loosened husks or husks removed over the germ or with one-third or more of the husk removed. Malting barley which has been harvested and threshed properly contains few skinned or broken kernels and often has short pieces of beard or awn still attached to the kernel. High yields of good quality malting barley cannot be produced unless it is:

- Cut at the right stage of maturity
- Swathed correctly
- Threshed correctly
- Handled carefully

Swathing Malting Barley — Barley for malt must be uniformly and fully ripe when it is harvested. It may be swathed without loss of yield or malting quality as soon as the crop has turned from green to light brown or buff color and the kernels contain from 30 to 35% moisture. Kernel moisture should be determined on samples of grain representative of the whole field, using a reliable moisture meter. Judging kernel moisture content on the basis of growth stages such as soft, mid or firm dough is not precise enough for producing high quality malting barley.

Malting barley should be swathed at a height of 15 to 20 cm to lay a swath that is light enough to dry quickly but heavy enough and overlapped well enough to feed properly and continuously into the combine. It is important to keep the swath off the ground to avoid discoloring the heads.

Combining Swathed Malting Barley — Malting barley swaths may be combined as soon as the kernel moisture content has been reduced to 14.8% or lower. Under dry, warm, breezy weather conditions, 3 to 6 days are usually required for such drying to occur. If swaths are allowed to dry excessively, there is more danger of peeling and cracking kernels in the combine. Malting barley seems to thresh best in early morning and late evening when kernels are dry but chaff and straw are slightly tough from dew.

To produce high quality malting barley, the combine operator must constantly check and properly adjust the machine to the varying conditions of the swath and weather throughout the day.

High cylinder speed is the major cause of excessive skinned and broken kernels. It is impossible to recommend any one cylinder speed for threshing malting barley. For a 56 cm diameter cylinder, the speeds for threshing six-row barley under fairly good harvest conditions will be about 850-875 rpm, but this must be reduced as the crop becomes drier as the day warms. Since two-row varieties of barley usually thresh more easily, cylinder speeds considerably slower than those cited should be used. Slower cylinder speeds must be balanced against the lowering of the combine's capacity. Cylinder rasp bars should be in good shape. Badly worn rasp bars have to be set too close to the concaves and will cause skinning. Rasp bars with sharp edges or burrs caused by stones will increase damage to kernels.

The space between concaves and the cylinder should be as close as possible, without causing overthreshing. Overthreshing results in too much straw break-up and overloading of the sieves. Close concaves will help separate grain from straw at the concaves. However, too close concave settings will skin kernels. Remember, maltsters do not mind seeing a short piece of awn left on each kernel.

Sieves should be adjusted to provide for the return of the smallest quantity of tailings. A heavy tailings return usually results in a high percent of skinned and broken kernels as they go through the cylinder the second time. Set the sieves well open and almost level or slightly elevated at the rear. Use plenty of wind on the front of the sieve. More barley is lost as a result of too little, rather than too much wind. Wind and sieve adjustments must be checked and adjusted as conditions change throughout the day. Adjust the forward speed of the combine to keep it operating at capacity load.

Operators of newly designed rotary-cylinder combines should consult their manuals for instructions on threshing malting barley. The effect of performance adjustments on rotary and conventional combines are very similar.

Remember! Careless swathing, threshing and handling can make feed barley out of otherwise good quality malting barley!

From the producer survey both the top and low group:

1. **Swathed their barley rather than straight combined.**
2. **Did not consider swathing or combining losses significant in 1981.**
3. **Did not swath as early as they could with respect to kernel moisture. The majority swathed at 20-25% seed moisture. Considering that a barley crop dries at a rate of about 2% moisture a day under normal dry weathering, this means that they could have swathed 5 to 10 days earlier.**

Possible reasons for the delay in swathing are:

1. **Waiting for immature second growth seeds to ripen.**
2. **Since the survey mainly involved the black soil zone where the fall is quite often characterized by cool, wet weather, some farmers want their crop in the swath for a minimum period of time. After a rain, standing mature barley will dry faster than in a swath, with less danger of sprouting. The more mature a crop is before it is swathed, the less dry-down time is needed in the swath.**
3. **The farmers did not know or could not recognize the recommended time to swath.**
4. **Time, machinery, weather restraints.**
5. **Do not believe 35-40% moisture is the right time to swath (30-35% seed and malt).**

Harvesting Lodged Barley

Lodged barley must be swathed at or near maturity, and windrowed to allow the green plants to dry before being threshed. Swathers should be equipped with pick-up reels

or extended cutter-bar guards to lift the grain before it is cut. Swathers equipped with ordinary reels and cutter bars tend to cut the lodged grain stems and allow the heads to fall to the ground. Severely lodged green barley usually produces low yields of poor quality grain which contains a large number of shrunken kernels.

It may be advantageous to cut severely lodged green barley for silage or dry fodder provided that such fodder can be utilized or marketed profitably. See pages 27 for harvesting of silage and dry forage.

Barley that is severely lodged near, or at maturity, may be utilized for high moisture grain or dry grain. It matures and ripens later than non-lodged grain because the soil dries more slowly under the blanket-like covering of lodged grain. Air movement is restricted under such crops. Because lodged barley usually remains damp for prolonged periods, kernels may bleach or discolor enough to affect market grade and acceptability for malting.

Lodged barley may be straight combined for high moisture grain and handled as outlined earlier in this publication. The combine should be equipped with a pick-up reel and extended cutter bar guards to assist in picking the grain from the ground. Because abnormally large amounts of straw are usually harvested from lodged grain, it may be necessary to reduce the width of cut to accommodate the threshing capacity of the combine.

Lodged mature barley may be swathed as soon as kernel moisture content is reduced to the appropriate level. It may be advisable to cut against the direction in which a majority of the crop is leaned or lodged, unless fields are very small. It may even be necessary to swath in one direction only, to avoid heavy losses of heads that lie near the ground. Acceptably sized uniform windrows can be made by altering the width of cut, depending on the severity and direction of the lodging.

The swaths are combined as soon as kernel moisture content reaches the level appropriate for the intended use of the grain. Swathing and harvesting of lodged barley usually takes more time than similar operations in upright crops.

Feeding Newly Harvested Barley

Newly harvested barley, whether dry, or high moisture, should always be stored about 4 to 6 weeks before being

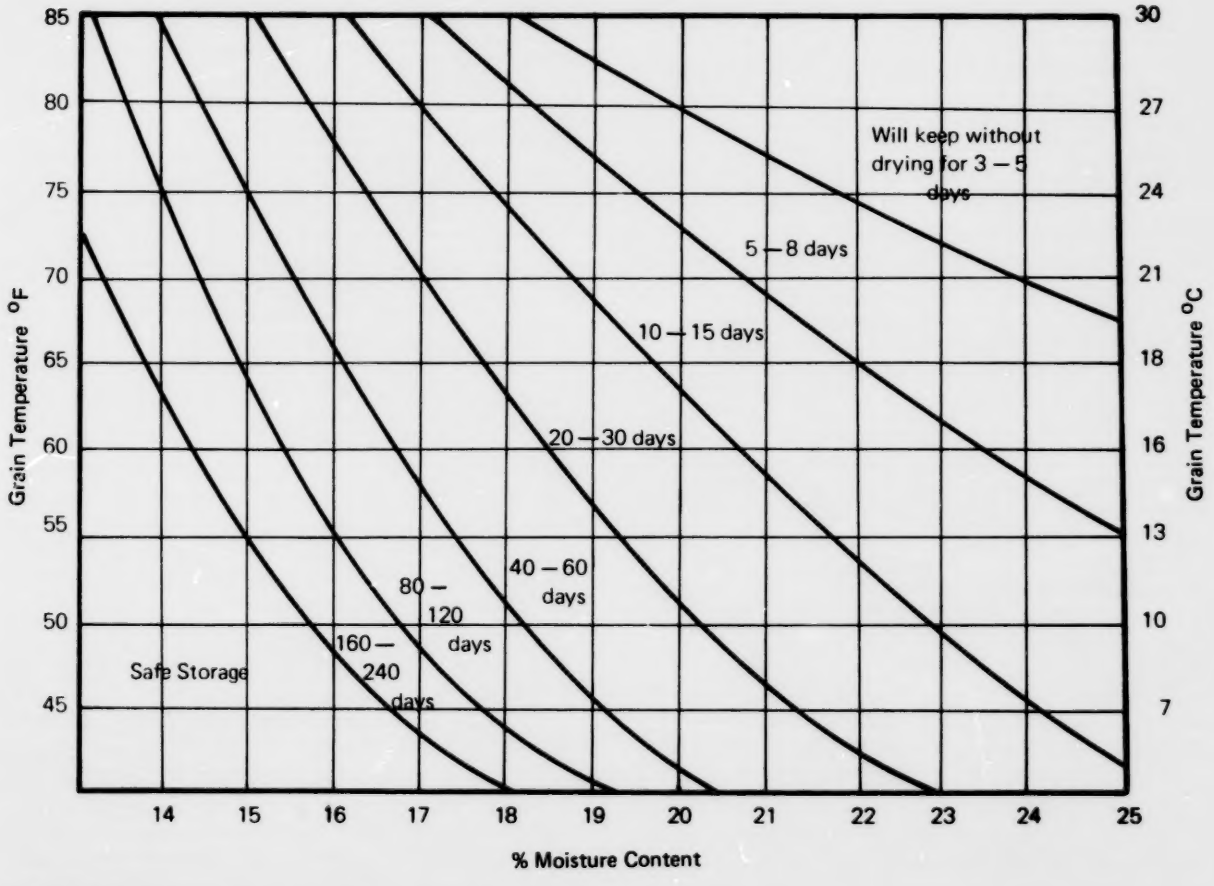

FIGURE 26. Storage time for grain at various temperatures and moisture contents.

fed to any class of livestock. This storage period is often called a sweat period. Serious losses in cattle, pigs and poultry have been attributed to feeding newly harvested grain. There is some evidence that certain compounds in the newly harvested grain may be toxic to livestock. In storage, such compounds undergo chemical changes that make them nontoxic. Processing newly harvested barley for feed apparently does not eliminate the problem of toxicity — a rest or sweat period is necessary.

Grain Drying

Grain drying is an accepted and recommended practice on many farms in central and northern Alberta. In southern Alberta, it is an occasional, though not unknown, practice.

Where grain dryers and proper handling and storage facilities are available, barley that contains as much as 20% moisture can be harvested and then dried without loss of grade, quality or germination. Grain dryers provide the producer with alternatives to normal harvesting times and methods.

Some advantages and disadvantages of drying grain are listed below:

Advantages

1. Allows for harvesting tough grain and thereby reduces losses to weather and wildlife.
2. Extends available harvest period.
3. Earlier harvest is possible.
4. Drying tough or damp grain can reduce or eliminate spoilage in storage.
5. May improve market grade and acceptability of grain.
6. May afford alternative market outlets for grain.
7. May eliminate necessity of swathing to obtain "dry" grain.
8. May improve malting quality by reducing kernel peeling and cracking during combining.
9. Since artificially dried grain usually contains near maximum allowable water content, the extra weight generates more dollars when sold.

Disadvantages

1. Requires extra capital for equipment, energy and operation.
2. Requires extra labor and inconvenience of handling unless centralized facilities are available.
3. Requires some experience to operate effectively.
4. May impair quality of malting barley if not operated properly.

Barley that contains more than 14.5% moisture is generally considered to be too damp to safely store. The length of time that damp barley can be stored safely, before drying, depends on the grain temperature and its moisture content. This relationship is shown in Figure 26.

Barley that contains more than 14.5% moisture tends to heat and spoil when it is placed in storage. It has little market value even as feed. Damp or tough barley should therefore be dried if it is to be stored more than a few days.

Barley that is placed in storage, at or near the maximum safe moisture content, may develop localized high moisture zones because of moisture migration. This is caused by changes in outside air temperatures which set up convection air currents in the storage bin. Moisture migration is most severe in barley stored in large bins when the grain is very warm. Such grain tends to spoil near the top centre of the bin in winter and near the bottom centre in summer. (See Figure 27 and Figure 28). To avoid this difficulty, such barley should be dried or aerated.

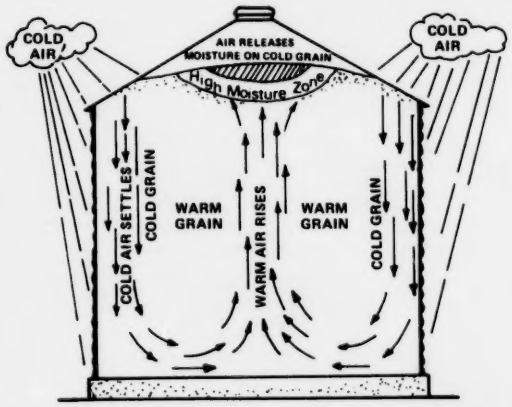

FIGURE 27. Diagram showing moisture migration in storage bin in cold weather.

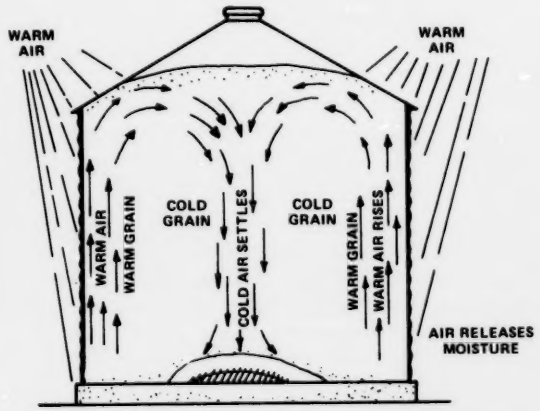

FIGURE 28. Diagram showing moisture migration in storage bin in warm weather.

There are three major types of dryers:

1. Non-recirculating batch type where the grain is loaded as a batch and remains stationary throughout the drying period.
2. Recirculating batch type where the grain is loaded as a batch but is constantly mixed and stirred while it is dried.
3. Continuous flow type where the grain is loaded and unloaded continuously or at least intermittently while it dries.

Because excessive heat can damage barley grain and reduce its ability to germinate, maximum safe air temperatures must not be exceeded. These are shown in Table 9.

TABLE 9 — MAXIMUM SAFE AIR TEMPERATURES ENTERING DRYER FOR BARLEY

Seeding and Malting	Commercial	Feed
45° C (113° F)	55° C (131° F)	80-100° C (176-212° F)

Barley Storage

Well-constructed granaries and bins are essential for proper long-term storage of barley. The best granaries are weatherproof, well ventilated, and of single-wall construction. Several small granaries are usually better than a few large ones because small lots of barley cool faster and more evenly than large ones.

Granaries should be built on well-drained sites to avoid danger of flooding and better accessibility.

Steel granaries usually require less maintenance, are more rodent proof, and provide fewer places for insects to live and multiply, than wooden bins.

Well constructed wooden granaries are also satisfactory for storing barley provided they are waterproof.

Barley may be stored temporarily in open bins constructed of plywood, paper or plastic-lined snowfence, or of bales of hay. Such bins must be placed on high dry ground to minimize grain spoilage and losses from ground moisture. Cone the grain as high as possible in the centre of open bins to shed rain and snow. Fill the bins to the brim to avoid free board between the grain and upper lip of the bin. Free-board space holds snow. Use a dark polyethylene sheet to cover dry grain but leave tough or damp grain uncovered to dry by exposure to wind and sunshine.

In emergencies, barley may be stored for short periods in conical piles on the ground. Cone the grain as high as possible in the centre of the pile without disturbing the natural slope of the sides and protect it from all disturbances.

Barley must not be stored in dirty granaries. Thoroughly clean the walls and floors of each bin. Remove old grain and dirt from all corners, cracks and crevices by sweeping and vacuuming. Where previously stored grain was infested with insects, spray walls and floors of the now empty granary with an approved insecticide about 5 days before storing new grain.

Fill the granary only to the top plate to provide crawl spaces for inspection, and for ventilation.

Never store newly harvested grain on top of old barley that may be infested with insects or contain spoiled grain.

If the barley has been stored in a "tough" (greater than 14.8% moisture) condition, examine it at least every 2 weeks by pushing your hand into the surface, as deeply as possible, to feel for warmth or crusting. Insert a long metal rod deeply into the grain to test for warmth and crusting at various depths. Feel the rod for warmth as soon as the rod is withdrawn from the grain. Cool dry grain seldom spoils in storage. Commercial temperature probes inserted into the grain will provide a more accurate indication of temperature.

Because insect infestations can mount very rapidly, all stored barley should be inspected every 2 to 3 weeks for signs of infestation, especially when the weather is warm. Heating caused by insect activity may be detected by looking for damp, crusty or lumpy areas in the grain. To check for insects, screen a representative sample of it with a 10-mesh sieve. Use a grain probe to obtain samples from within the pile.

In winter, insect infestations in barley can usually be controlled by cooling the grain. Move it several times with augers so as to expose the grain to cold temperatures. Drop the temperature of the grain to about 5° C if possible.

If moving the grain fails to control an insect infestation, fumigation may be necessary. Instructions for fumigation may be obtained from district agriculturists, agricultural fieldmen, and certain registered pesticide applicators.

Future Markets

Opportunities for expansion in traditional markets will depend on factors outside of the control of the grower. For the foreseeable future, Canada, as well as Alberta, will have barley which is surplus to domestic requirements and will depend on export markets. The international market for feed barley fluctuates widely, but the market for malt and malting barley is relatively stable. We can anticipate some increases in exports but there are major difficulties.

World demand for malting barley and malt is for high quality two-row, and this demand is growing with increasing beer consumption. Unfortunately, Canada's share of this market is not growing. From 1971-1980 Canadian exports of malting barley remained constant at around 400,000 tonnes (about 18 million bushels). Exports of malt during the same period increased from 80,000 to 200,000 tonnes, but our share of the market remained nearly constant at around 10% of the international trade.

Subsidized competition from some countries (particularly France) in the European Common Market has been formidable in export markets. Artificially high farm prices in the E.C.M. encourage overproduction. Subsidies are used to bring the price of exported barley down to, or below, the international price level in order to dispose of these surpluses.

A further difficulty is that much of our malting barley is higher in protein content than that preferred on the world market. Unfortunately, the soil and climate that contribute to the production of high protein hard red spring wheat also tend to produce barley with high average protein content. The grading system that has been so effective in providing a reliable and uniform supply of hard red spring wheat to world markets does not do the same for malting barley. Some low protein barley is produced in Alberta, but if this is blended with higher protein barley in the same grade, the average protein content is increased. Malting barley for export is selected on a sample basis and is acceptable in world markets when offered in cargos that are satisfactory as to variety, protein content, and other quality factors.

Prospects for increased exports of malt are somewhat better. Domestic maltsters have been able to select, and bring to the plant, carloads of barley that could be processed to provide malt that is very acceptable in world

markets. They have maintained a share of the markets against severe competition. Existing plant capacity and planned new capacity will allow increased malt production to keep up with anticipated increases in exports.

New Developments

Varieties:

Further improvement in the varieties grown would help to improve quality of barley and malt. However, two-row malting varieties are rather closely related, so future improvement will be difficult to attain. They are inherently very similar in protein content. Variations between varieties are the result of interactions with environment, with the best adapted varieties tending to be somewhat lower in protein content.

Malting vs Feed Barley:

Many Alberta farmers plant malting varieties in the hope of selling at least part of the crop for malting. Consequently, 80% of the acreage is planted to varieties acceptable for malting, while only 10% of the crop is marketed as malting barley. In most other barley producing countries, the proportion of the acreage planted to malting varieties is much closer to market requirements. For example, in Britain, with a barley acreage about the same as that of Alberta, malting varieties occupy only about 30% of the seeded area. The best interests of a majority of Alberta producers would be served if production was more closely tailored to available markets. The seeding of higher-yielding feed varieties is likely to be a future trend.

Winter Barley:

Winter barley, which is sown in the fall, is not hardy enough for Alberta. An occasional crop of a hardy variety may survive some winters in southern Alberta, but attempts to grow it continuously have always failed. A major increase in winter hardiness would be required for successful production in Alberta. Varieties with this degree of winter hardiness are not available anywhere in the world, and winter barley will not be a commercially viable crop in Alberta in the forseeable future.

Hybrid Barley:

Hybrid barley attracted considerable attention a number of years ago because of some experimental evidence for hybrid vigor in the first generation of crosses between varieties. Experience has shown the equivalent gains in yield can be achieved by conventional breeding, and in a self-fertilized crop such as barley, the cost of producing hybrid seed is excessive. Most breeding work on hybrid barley has been discontinued.

Feed Barley:

Feed barley has been considered primarily as a source of energy and little effort has been directed toward improving nutritional quality. Some work is underway and varieties with improved nutritional quality can be expected. The recent release of the naked variety, Scout, with low fibre content and higher protein, is an improvement for monogastric animals. Breeding for high lysine content is also occurring. Current varieties are higher in lysine content than other cereal grains but are still deficient and must be supplemented when fed to hogs. Varieties with improvements in other essential amino acids can also be expected in the future.

Improved amino acid content in barley is of no significance for feeding ruminant animals. However, recent research indicates that carbohydrate composition of the grain may be important for feeding cattle. Further research is being conducted to verify these results.

Industrial Uses:

Carbohydrate composition is known to be important in industrial processes. Barley lines high in specific carbohydrate fractions have been developed at the University of Montana. The feasibility of commercial production and utilization of these lines in producing barley syrup is under investigation.

There is much current interest in alcohol as an alternative fuel for internal combustion engines. Dwindling supplies of conventional petroleum, and increased costs of production of new petroleum supplies mean that new energy sources will be used. If alcohol is ever used as an alternative fuel in western Canada, it will no doubt be produced from barley. However, it is not competitive with petroleum at current prices as the energy costs of converting barley to alcohol are high. Current research at the University of Saskatchewan indicates that rapeseed oil may be more competitive with diesel fuel for use in farm tractors.

New Technology:

Average yields of barley in western Canada have more than doubled in the last 35 years. In the mid-forties yields averaged a little over 900 kg/ha (20 bu/ac), while in recent years they have been about 2000 kg/ha (45 bu/ac). Improvements in farm machinery, new herbicides, insecticides and fungicides, increased fertilizer use, and new barley varieties have all contibuted to the increase.

Future increases in yield will be more difficult. Major reductions in losses from weeds, insect pests, and plant diseases have already been achieved and additional reductions will of necessity be smaller. Farm machinery improvements already permit more timely field operations and make possible optimum crop response to the environment during the growing season.

There is still an opportunity for increased yields through more and better fertilizer use, new barley varieties, and the full implementation by farmers of currently known technology. As in the past, the development of better varieties will be slow and improvements in yielding ability in each new variety will be relatively small. Genetic advances similar to those of the past can be expected (average of about 1% a year for the 80s). A larger number of varieties, each suitable for a specific region, would increase average production.

Implementation or utilization of the presently known best production techniques by all farmers would probably have the greatest impact on raising the provincial yield average and prosperity of our farmers. Before a producer can utilize these methods, he has to be made aware of them. That has been the purpose of this manual.

Appendix 1

Barley Varieties

The barley varieties described in this appendix were licensed for sale as seed in Canada as of the 30 September, 1982 and, except for new varieties, were grown commercially in Alberta up to that date. Varietal descriptions are not complete, but strengths and weaknesses are outlined, and an attempt is made to indicate where each variety is most useful in Alberta.

Reactions to barley diseases are given only when varieties are resistant or very susceptible. Very few have a high degree of resistance to the barley diseases that are prevalent in Alberta. However, most are tolerant to the diseases that occur in the areas where they are adapted and usually escape damage. Varieties that would suffer serious yield losses because of susceptibility to diseases are almost always eliminated in the stringent selection and testing required before they can be licensed.

Six-Rowed Varieties Eligible For Feed Grades Only

Galt was developed at the Lethbridge Research Station. It is high yielding, drought tolerant and resistant to lodging and shattering. It is medium in maturity with moderately short straw. It is resistant to covered and false loose smut, but susceptible to loose smut. Galt is widely adapted and was grown extensively in western Canada, but newer varieties have replaced it in many areas. New varieties are more productive than Galt in northern and central Alberta, but not yet in southern areas.

Klondike was developed at the Brandon Research Station. It is high yielding, widely adapted, lodging resistant, and has no serious agronomic defects that often result in major yield losses. It is medium in maturity and moderately resistant to root rot, and loose, covered and false loose smut. Klondike out-yields Galt in most parts of central and northern Alberta, but yields a little less in southern areas.

Diamond was developed at the Lacombe Research Station and licensed in 1982. It is 2-4 days earlier than Galt and Klondike, and is similar to Galt in disease reaction, loose smut susceptibility, and lodging resistance. It is more resistant to net blotch than currently available varieties. In tests in central Alberta it has been superior in yield to Klondike, but further testing will be needed to establish its area of adaptation. Because of Diamond's good yield to maturity index and tolerance to net blotch, it should be very useful in many areas of central and northern Alberta.

Empress was developed by Alberta Agriculture at Lacombe and licensed in 1982. It is 2-4 days earlier than Galt, and resistant to lodging. It is moderately susceptible to scald and susceptible to loose, covered, and false loose smut. It shows field resistance to scald and net blotch and has outyielded Galt in testing in central Alberta, and it appears to be particularly well suited to high moisture and silage production in the Parkland. More testing is required to establish its best area of adaptation.

Johnston is a very high yielder but is late maturing and susceptible to lodging and shattering. It is moderately resistant to scald and root rot, but susceptible to covered and false loose smut. Johnston was developed at the Brandon Research Station and licensed in 1980. Its suitability for Alberta has not been fully assessed.

Melvin was developed at the University of Saskatchewan. It is very similar to Galt. It has yielded somewhat more than Galt in east-central and northern Alberta, but is essentially the same as Galt in other areas.

Otal was introduced from Palmer, Alaska by the Beaverlodge Reseach Station and licensed in 1981. It is very early and higher in yield than Olli or Gateway 63, making it most suitable in areas of northern Alberta, where earliness is essential. It is susceptible to root rot, but moderately resistant to covered smut.

Windsor is medium in maturity, rather susceptible to lodging, moderately resistant to scald, and susceptible to common root rot. Windsor was developed at the University of Alberta, and yields well on the black soils of central Alberta. However, Klondike yields as well in those areas, and has other advantages.

Six-Rowed Varieties Eligible For Malting Grades

Bonanza was developed at the Brandon Research Station and licensed in 1970. It is medium in maturity, lodging resistant, and moderately resistant to root rot. Bonanza yields less than the best feed varieties, but will usually return more per acre if it can be marketed as malting barley. It is the predominant malting variety in western Canada.

Conquest was developed at the Brandon Research Station and licensed in 1965. It is of medium maturity, resistant to lodging and moderately resistant to root rot. It is lower yielding than Bonanza, but a little earlier and can be grown profitably in Parkland areas, if it can be marketed as malting barley. It withstands delayed seeding better than most barley varieties, but will still have a reduced yield.

Gateway 63 was developed at the University of Alberta and licensed in 1963. It is early, moderately resistant to lodging, and susceptible to root rot. It yields somewhat less than Conquest and is less acceptable to maltsters. Consequently, its use is limited to conditions where early maturity is important.

Olli was introduced from Finland and licensed in 1935. It is very early but low-yielding and susceptible to scald and root rot. It was a major variety in Alberta for many years. Large quantities of Olli were used for malting, but Conquest and Bonanza are preferred now. It does not withstand delayed seeding.

Argyle is a new six-row variety developed at the

University of Manitoba. It is about one day later than Bonanza, about 3-4% higher yielding in the black and grey wooded soil areas, and considerably stronger strawed. Preliminary malting tests show it to have some advantages over Bonanza. This must be confirmed by further malting trials.

Two-Rowed Varieties Eligible For Feed Grades Only

Abee was developed by Alberta Agriculture at Lacombe and licensed in 1982. It is medium in maturity, has good lodging resistance, and is moderately resistant to root rot. In yield trials to date it has been superior to existing two-rowed varieties, and approaches the yield of the best six-rowed feed varieties in many areas.

Harrington was developed at the University of Saskatchewan and licensed in 1981. It is medium in maturity, lodging resistant, and moderately resistant to root rot. It appears to be adapted to the two-row areas of Alberta. Harrington has good malting and brewing quality, but, because of its similarity in kernel type to the feed variety Fergus grown in Manitoba, it can currently grade no higher than No. 1 feed. Under cool, moist harvesting conditions sprouting can be a serious problem.

Norbert was developed at the Winnipeg Research Station and licensed in 1980. It is medium to late in maturity. It is very resistant to lodging, resistant to net blotch, but susceptible to common root rot. Norbert is well adapted to the eastern prairies, but further testing is required to determine its suitability in Alberta. It has excellent brewing and malting quality, but because of its resemblance to Fergus, can currently grade no higher than No. 1 feed.

Scout is a naked seeded variety developed at the University of Saskatchewan and licensed in 1982. Naked or hulless varieties have been grown in Alberta on a very limited scale, and used for feeding young pigs, where low fibre content is highly desirable. Scout is the first hulless variety bred specifically for western Canada. In limited yield trials Scout has yielded 12-15% less than Fairfield. However, because barley hulls are of little or no feed value for monogastric animals, Scout is reasonably equivalent to Fairfield in energy yield per unit acre for this class of animal. Scout is higher yielding than our best hard red spring wheat varieties. It is very susceptible to smuts.

Summit was introduced from Europe, licensed by a private company, North American Plant Breeders, and distributed in Canada through agents. It is late maturing, very resistant to lodging, and high yielding when soil moisture is adequate. However, it does not yield more than other varieties available in the two-row areas of Alberta, and, because numerous samples of seed have been found to contain leaf stripe, its production can be hazardous.

Two-Rowed Varieties Eligible For Malting Grades

Betzes was introduced from Europe via the U.S.A. by the Lethbridge Research Station and licensed in 1960. It is medium in maturity and lodging resistance. It is well adapted to the two-row barley areas of Alberta and western Saskatchewan, but its susceptibility to leaf diseases has made it unsuitable for other areas. Our important two-row malting market in the U.S.A. was developed with Betzes, but Klages is now preferred in that market.

Klages was developed at Aberdeen, Idaho, and licensed in Canada because of its superior malting and brewing quality. It is late maturing, moderately resistant to lodging, resistant to covered smut, and is more resistant to leaf diseases then Betzes. It is very susceptible to sprouting and shattering. Klages yields about the same as Betzes in the two-row areas of Alberta. It is preferred for export as malting barley as well as for domestic malting.

Elrose is a medium maturing, lodging resistant variety developed at the University of Saskatchewan. It is similar to Klages in malting quality and a little higher yielding in the two-row areas. It was malted and brewed on a large commercial scale for the first time with the 1981 crop. Whether it will be fully acceptable to the trade is not yet determined.

Fairfield was developed at the Lethbridge Research Station. It is medium in maturity, resistant to lodging and shattering, and less susceptible to smuts and leaf diseases than Betzes. Fairfield is equal to Betzes in malting quality and higher in yield, but has not been bought for malting on a large scale because of similarity of the seed to Fergus and Herta.

Hector is a drought tolerant variety developed at the Lethbridge Research Station and licensed in 1973. It is medium late in maturity, resistant in shattering, medium in lodging resistance, and moderately resistant to loose and covered smut. Hector is equal to Betzes in malting quality, but has not been bought on a large scale for this purpose. It is particularly well adapted to the drier grassland areas where it is the most productive variety available.

Appendix 2

Suggested Reading: Publications with Agdex numbers are available from Alberta Agriculture.

Agdex No.	
FS100/32	Varieties of Cereal and Oilseed Crops for Alberta
FS100/622	Chemical Control of Field Crop Insects
100/605	Spoilage of Farm-Stored Grain by Molds, Insects, and Mites in Western Canada. AC 1437, 1971
100/623-2	Insects and Mites on Farm Stored Grain in the Prairie Provinces. AC 1595, 1976
110/632	Ergot of Grains and Grasses
FS120/52-1	Silage in Alberta
518	Farming Acid Soils in Alberta and Northeastern British Columbia. AC 1521, 1974
518-1	Management of Saline Soils
518-2	Solonetzic Soils and their Management. AC 1391, Revised 1977
FS518-8	Management of Solonetzic Soils
FS534-1	Liming Acid Soils
FS541-1	Alberta Fertilizer Guide. Revised 1981
FS622-4	Control of Grasshoppers in Alberta
FS640-5	Controlling Weeds Root Rots of Barley
641-9	Guide to Weed Control in Alberta. Part 1 — Chemical. Revised 1982
736	Heated-Air Grain Dryers. AC 1700, 1980
736-11	Movement of Natural Air Through Grain. 1980
—	Compendium of Barley Diseases — Published by the American Phytopathological Society 3340 Pilot Knob Road, St. Paul, Minnesota, 55121, U.S.A. Priced approximately $12 U.S.

CONVERSION FACTORS FOR METRIC SYSTEM

Imperial units	Approximate conversion factor	Results in:	
LINEAR			
inch	x 25	millimetre	(mm)
foot	x 30	centimetre	(cm)
yard	x 0.9	metre	(m)
mile	x 1.6	kilometre	(km)
AREA			
square inch	x 6.5	square centimetre	(cm^2)
square foot	x 0.09	square metre	(m^2)
acre	x 0.40	hectare	(ha)
VOLUME			
cubic inch	x 16	cubic centimetre	(cm^3)
cubic foot	x 28	cubic decimetre	(dm^3)
cubic yard	x 0.8	cubic metre	(m^3)
fluid ounce	x 28	millilitre	(mL)
pint	x 0.57	litre	(L)
quart	x 1.1	litre	(L)
gallon	x 4.5	litre	(L)
WEIGHT			
ounce	x 28	gram	(g)
pound	x 0.45	kilogram	(kg)
short ton (2000 lb)	x 0.9	tonne	(t)
TEMPERATURE			
degrees Fahrenheit	(°F -32) x 0.56 or (°F -32) x 5/9	degrees Celsius	(°C)
PRESSURE			
pounds per square inch	x 6.9	kilopascal	(kPa)
POWER			
horsepower	x 746	watt	(W)
	x 0.75	kilowatt	(kW)
SPEED			
feet per second	x 0.30	metres per second	(m/s)
miles per hour	x 1.6	kilometres per hour	(km/h)
AGRICULTURE			
gallons per acre	x 11.23	litres per hectare	(L/ha)
quarts per acre	x 2.8	litres per hectare	(L/ha)
pints per acre	x 1.4	litres per hectare	(L/ha)
fluid ounces per acre	x 70	millilitres per hectare	(mL/ha)
tons per acre	x 2.24	tonnes per hectare	(t/ha)
pounds per acre	x 1.12	kilograms per hectare	(kg/ha)
ounces per acre	x 70	grams per hectare	(g/ha)
plants per acre	x 2.47	plants per hectare	(plants/ha)